December 2010

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Science Reporter

A CSIR Publication

The Laser turns 50

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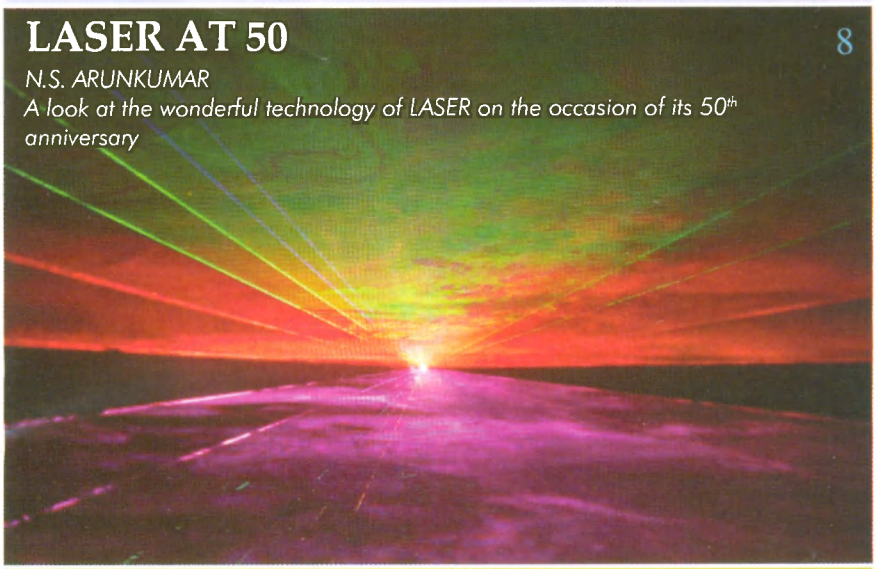
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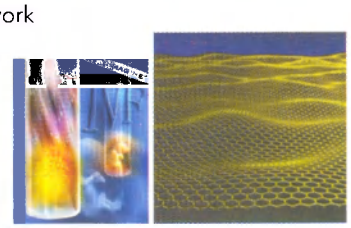
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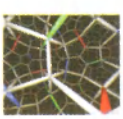
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NANDITA

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Talent Vs Technology

The article **Hi Tech Sports** by N.S. Arun Kumar (October 2010) gives a great deal of information about the technological advancements that have crept into the sports arena. There is a lot of talk about technologies helping players to enhance their performance manifold. I do agree to some extent, but I think talent is what matters in the end to decide the winner or to give him/her a



winning edge because the same technology is available to one and all. It finally depends on the talent that the players have. In the past also when the present technologies were not available, talent mattered the most.

The advancements in technology have helped sportspersons set new records. For example, Usain Bolt's record in 100 m is really extraordinary in the sense that nobody had it before him. Completing the race in less than 9.5 seconds is amazing. This is perhaps the result of taking the help of new technology that has helped give better performances than the past.

Sidharth Sankar Baliarsingh
1st year BTech (ME), GITA, Bhubaneswar
chandansankar@gmail.com

Of the Royal Society

The feature article, **Royal Society Turns 350,** in the September issue was indeed excellent in terms of information and content. It probably needs to be mentioned in this context that the full name of the society is 'The Royal Society of London for Promoting Natural Knowledge' and that the society didn't encourage any woman as its fellow till 1944. It was only in 1945 that two ladies, both English, were first made fellows of this august and prestigious society in its 350 years of existence so far.



Of the Indian links mention needs to be made of the two great Indian scientists Acharya Satyendranath Bose and Dr Sisir Kumar Mitra who both were made FRS in 1958 – the distinction earned in the post-independent India.

Ashoke Datta
Assam

Cancer Info

The feature articles, **Cancer in Children** by Vishwas B. Chavan, **Dendrimers: New Hope for Cancer** by Subha S. Ghosh, and **Role of Bioinformatics in Cancer** by Aparna Chaudhuri and Santanu Chaudhuri were very illustrative, informative and interesting. Since the language of the articles was very simple, the information was especially useful for me and my *Bhoomi* club.



I am keen to begin a career in Biotech. I am a recent graduate who combined studies with working in Q.C. lab in milk product. I know some basic information about cancer but the information provided in the magazine was very informative and helpful. I want to say thanks to the *Science Reporter* family.

Sanjay Ghorpade
Kolhapur, Maharashtra

No Water, No Life

The editorial **Nurturing Water Reservoirs for a Better Future and the article There Goes the Eilixir of Life – Water** were very informative. There are several factors responsible for the Water Crisis in our country – growing population with every day, diminishing rain water, increase in industrialization, urbanization with no focus on conserving water resources and so on. It is observed that most of the pipelines made by Municipal authorities wear out early resulting in wastage of water on a large scale in almost all cities of India. Water in national rivers like Ganga, Yamuna and Brahmaputra are getting contaminated because of industrial sewage thrown in them. People as yet do not understand the importance of water and their responsibility in saving water.

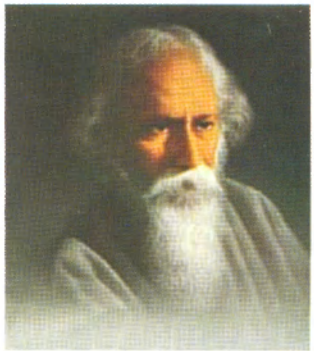


Prof Prakash Manikpure
Nagpur

Remembering Tagore

The September issue of *Science Reporter* was really attractive for its rich articles on various issues, especially the article **Rabindranath Tagore: Literary Giant with Scientific Bent** by Mr Koushik Roy. Thanks to the writer as well as the editorial board for the right choice at the right time when our country is celebrating the 150th birth anniversary of this great Poet. The content and concept of the article was very informative.

The article **Psychosis of Schizophrenia** by PC. Chawla is more important from the viewpoint of those who are caring for the patients. The statement that "with no fool proof care, the trauma of Schizophrenia can only be lessened through



compassionate care and efforts to reintegrate the victims into society" would be valuable advice to family members.

Somnath Chanda
West Bengal

Great Help

I have been reading *Science Reporter* for the past two years. I am living in a remote area of Bihar studying in class eight in a D.A.V. School. This magazine helps a lot in getting scientific knowledge. I am very fond of discussing the articles published in *Science Reporter* with my friends. It is also a great help for me in science debates.

Rohan Raj
Bihar

HAVE YOUR SAY

If you feel strongly about any article or write-up published in *Science Reporter* or have some information to share with the readers, please write to us at the postal address given in the magazine or send an Email at sr@niscair.res.in.

Science Reporter

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HASAN JAWAID KHAN

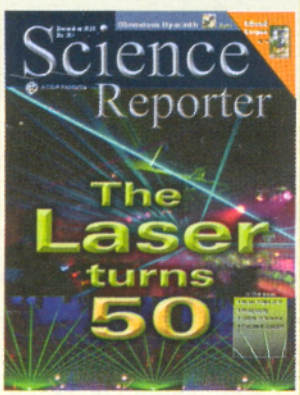
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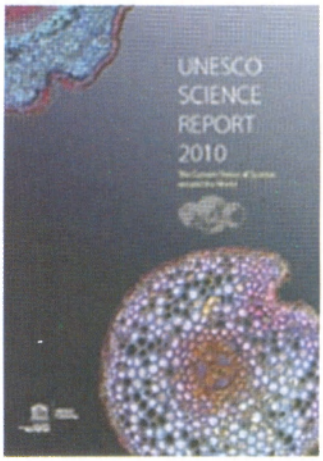
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COVER DESIGN
NEERU SHARMA

Indian Science—As the World Sees It

Last month we talked about a vision document for Indian science released by the 32-member Science Advisory Council to the Prime Minister (SAC-PM). The 47-page report, "India as a Global Leader in Science", charted a roadmap for the growth of Indian science for the next 20 years counting on the youthfulness of the Indian population as a major advantage, recognizing the need for roping in the best teaching talent, the imperatives of creating a huge scientific work force, calling for bigger investments in science, and above all, creating a culture of innovation and entrepreneurship in the country.



This month we review the contents of another recently released report, the ***UNESCO Science Report 2010: The Current Status of Science Around the World,*** *in an effort to gauge how the world sees us conducting our science. But before that we take a look at what the Report outlines as some of the broad trends that have characterized the past decade vis-a-vis scientific growth throughout the world.*

Primarily, according to the Report, the revolution in R&D in the past decade has come about thanks to cheap and easy access to new digital technologies such as broadband, Internet and mobile phones, which have also facilitated the setting up of R&D centers at remote locations abroad to soak in the benefits that the new locations have to offer.

Secondly, the highly developed nations no longer have the sole grip over knowledge-intensive growth. The Report points out that other countries are fast catching up as far as their investments in tertiary education and R&D are concerned. And finally, the global economic recession seems to have given the Western S&T dominance a sound challenge. Whereas Europe and the USA are struggling to free themselves from the grips of the recession, firms from emerging economies like Brazil, China, India and South Africa are witnessing sustained domestic growth and moving upstream in the value chain, says the UNESCO Report.

Coming to India, Chapter 17, devoted to India, refers to it as one of the world's fastest growing economies, alongside China. Having sidestepped the global recession, India has been seeing a steady rise in private investment in R&D. With more and more foreign companies establishing R&D centers on Indian soil, most of these focusing on ICTs, the country has become the world's leading exporter of IT services. In fact, the Report points out how firms from India are also buying up large firms in developed countries thereby acquiring the firms' knowledge capital overnight. Aerospace exports are also growing by 74% a year.

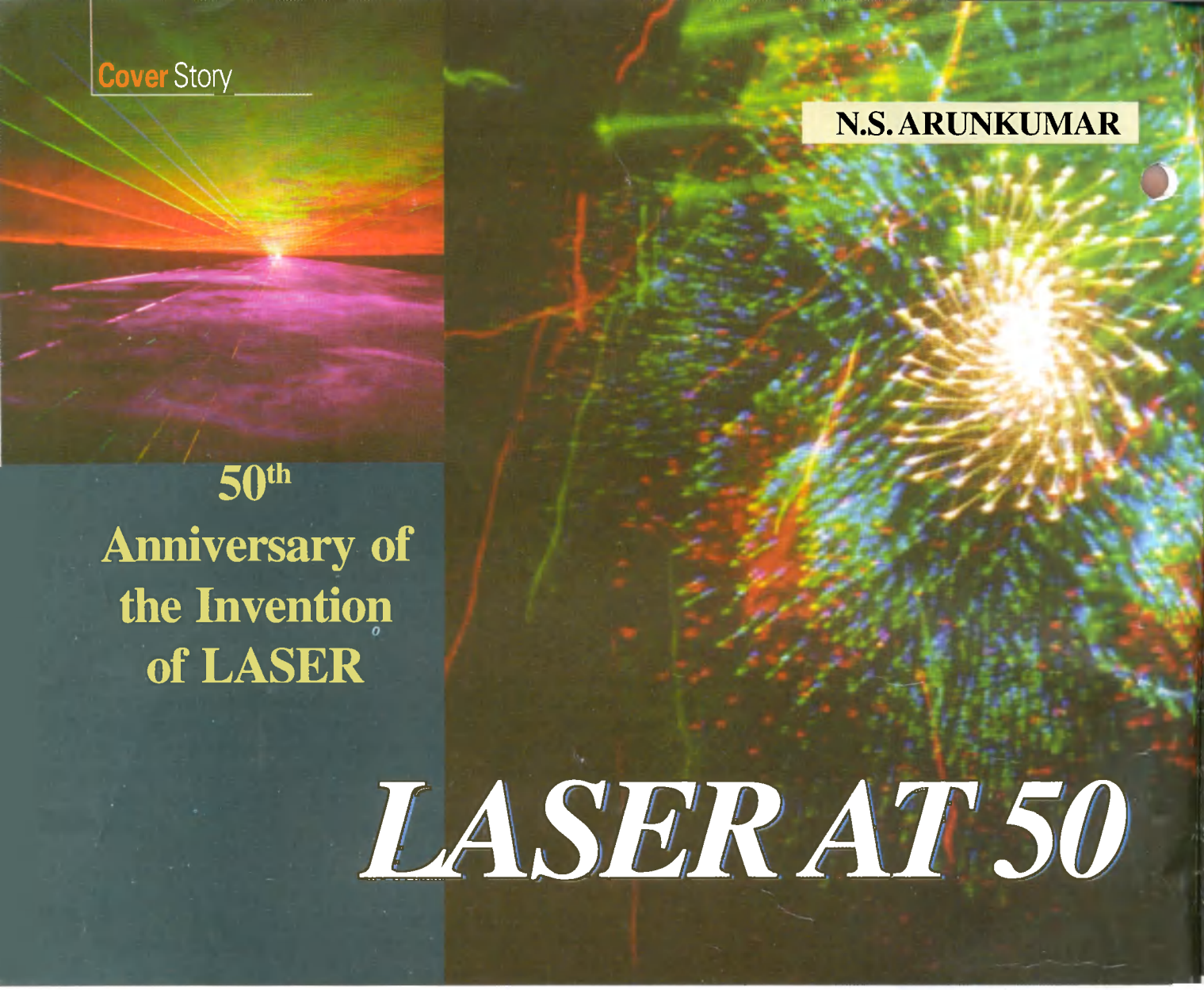
The adoption of the Indian Patent Act in 2005 to bring India into compliance with the TRIPS agreement did not cause the domestic pharmaceutical industry to slump, contrary to expectations. In fact, emphasizes the UNESCO Report, the pharmaceutical industry is flourishing, even if the domination of foreign firms in patents continues to cast a shadow. India's share of global patents, barely 0.2%, is a cause for concern as is the fact that most of the patents are being granted to foreign companies located in India, based on R&D projects carried out in India.

The biggest challenge of all, according to the report, will be for India to improve both the quantity and quality of Indian S&T personnel. In this context, the central government's decision to create 30 universities across the country, including 14 world-class innovation universities, augurs well for the future.

Hasan Jawaid Khan

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N.S. ARUNKUMAR



50th Anniversary of the Invention of LASER

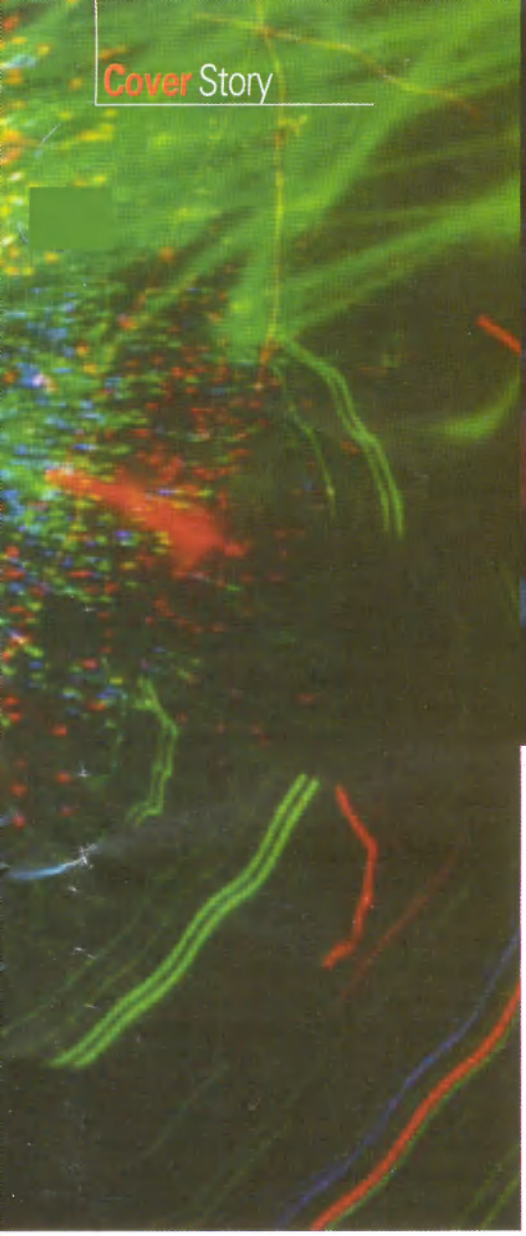
LASER AT 50

In the LASER we have a sort of Alladin's Lantern. All that we need is imagination to order it to perform tasks that we want done. Here's a look at this wonderful technology on the occasion of its 50th anniversary.

ON 21 July 1969, before leaving for Earth, astronauts Neil Armstrong and Edwin Aldrin had set up an array of small reflectors on the surface of the Moon. About ten days later, a team of astrophysicists at University of California's Lick Observatory pointed their telescope towards the precise location of human landing and sent a small pulse of power into the tiny instrument they had added to the telescope. The narrow beam of red light that emerged from it pierced the sky and disappeared into outer space. Slightly more than a second after the beam hit the reflectors, the Lick team detected its faint reflection. The time period between the launch of the pulse of light and its return permitted calculation of the distance between Earth and Moon with unprecedented precision, to the extent of correction within an inch.

The wonder ray that made this possible was LASER, a brand new invention that had been demonstrated just nine years before, in 1960. It was the brainchild of a 32-year-old engineer-turned-physicist at Hughes Research Laboratories, Malibu, California. His name was Theodore Maiman, but at that time it was considered rather useless, upon which even his colleagues mocked him, saying, "Aha! Great solution! But what could be the problem?"

In fact, nobody could even imagine that Maiman's invention would become literally the workhorse of modern physics and so engraved on to everyday life. And today in its fiftieth birth anniversary, LASER is here to cool atoms, send data, mend eyes and trigger





Laser lights make for fascinating viewing

fusion. While it is the "death ray" in military applications, it is forming part of high-life through spectacular "LASER shows" at stage concerts. It is there in our DVD's, Bar-code scanners and latest mobile phones and so, simply but, it is unavoidable.

History of LASER

It goes to Einstein for a starting point in the history of LASER, who at the prime of his fame established the idea of stimulated emission, in 1917. It was a re-derivation of Max Planck's Law of Radiation through conceptual advancement. However, till the end of the 1940s, the principle of stimulated emission was hardly sought, as the concept was largely considered a theoretical one.

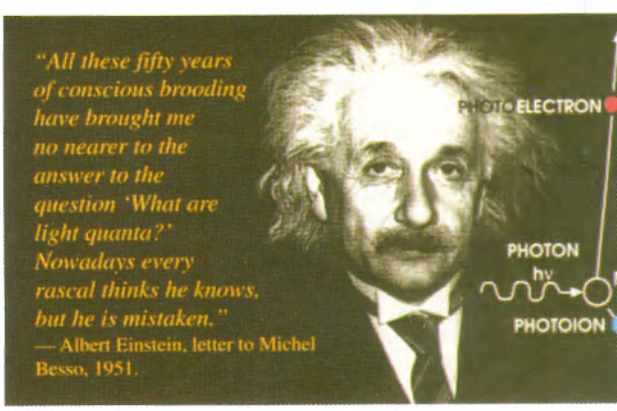
Einstein based it in thermodynamics, that if light can force an atom to go on to high energy states, it can also force an atom to give up its energy and drop to lower states. While this "stimulated energy loss" happens, it will also lead to amplification of the emitted photon, a phenomenon called Coherent Amplification. In short, it is amplification stimulated by light creating a stronger emission (later abridged as LASER – Light Amplified by Stimulated Emission of Radiation).

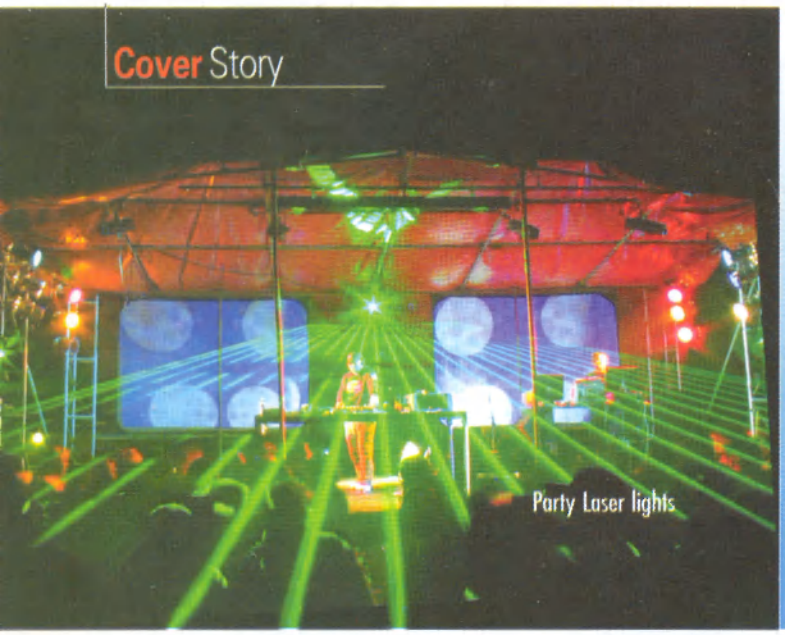
In 1918 itself Einstein had predicted the existence of gravitational waves produced by moving masses. But until today it has not been directly detected.

The first brilliant success was by Charles Townes, who used this phenomenon to amplify the microwaves. The resultant device was called MASER, the acronym for 'Microwave Amplification by Stimulated Emission of Radiation'. And in their historical paper published in *Physical Review*, Townes and his co-worker Arthur Schawlow hoped that the MASER concept could be extended to an "optical MASER", in other words, the LASER.

Thus, it paved the way for a race to build a LASER, in which Bell Laboratories was destined to win as the research group led by Charles Townes was there. Bell Lab, then called the Bell Telephone Laboratories, was a well-funded research institute with a backdrop of several high profile achievements. Even within Bell Lab there were other groups, well, outside also, who joined the race.

In US alone, there were more than six research labs including the famous General Electric and IBM. Townes's former PhD student, Gordon Gould, was also among the rivals. He abandoned his thesis work and joined a private company engaged in LASER research. But, the dark horse was yet to join the race—Theodore Maiman, who was then at Hughes Research Laboratories, the research arm of Hughes Aircraft Company. Maiman's engineering and physics experience was an added advantage, when the company wanted a MASER, as per the contract it signed with the US Army







Lasers are embedded in everyday life finding use in DVDs, bar code scanners, mobile phones, as military weapons, and even in surgery

Corps of Engineers. It was his efforts to make the MASER more compact and practical that led to the LASER.

Maiman's "Eureka"

The reason why light is usually absorbed in materials is simply that substances almost always have more atoms or molecules at lower states than at higher states so that more photons are absorbed than emitted. So, the trick in making a LASER is to produce a material in which the energies of the molecules or atoms are put in excited states than in ground states. A wave of electromagnetic energy moving through such a substance will pick up, rather than lose energy.

However, just one pass of the wave through the substance will not give much amplification and so multiple reflections have to be there. This is achieved by placing two parallel mirrors on either side of the material, of which one mirror is partially transparent. When the internal reflections are enough to build up substantial amount of power, the ray will penetrate through the transparent mirror. This was the theoretical blueprint and next came the choke of the material.

Maiman was familiar with the properties of Ruby from his earlier works and so he selected it. Ruby is a crystal of Aluminum Oxide (Al_2O_3) in which a few Chromium atoms are dispersed as impurities. These Chromium atoms that exist as ions by losing three of their electrons can absorb green light from the visible spectrum and go to excited states. When electrons fall back to the ground state from these high energy levels, they fluoresce in red. Maimam was thinking that he could use this red fluorescence to create LASER.

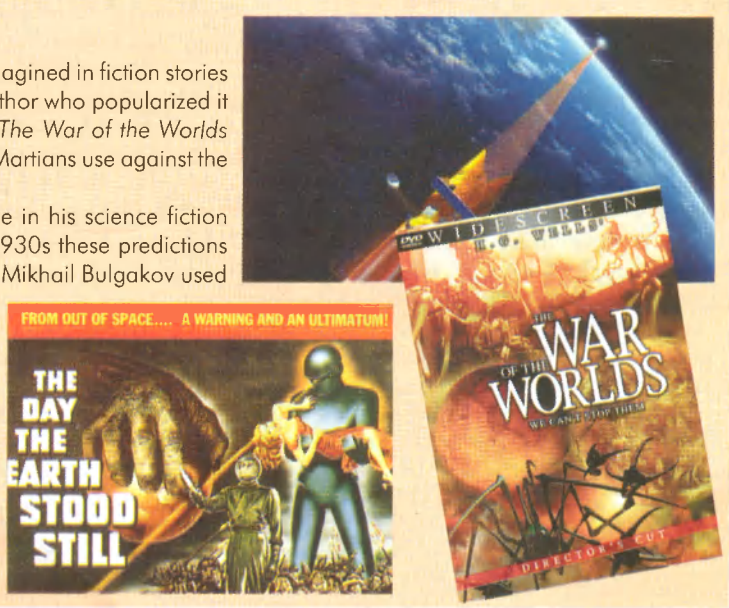
The path ahead was however not smooth as he thought. The first blow came from Arthur Schawlow who was his brother-in-law and work-mate. In September 1959, shortly after Maiman started his project, Schawlow publicly declared that Ruby couldn't be a candidate for stimulated emission. He argued, for that to happen, more electrons need to reside in the upper energy level than in the lower ones, a condition known as 'Population Inversion'. As per Schawlow, it was

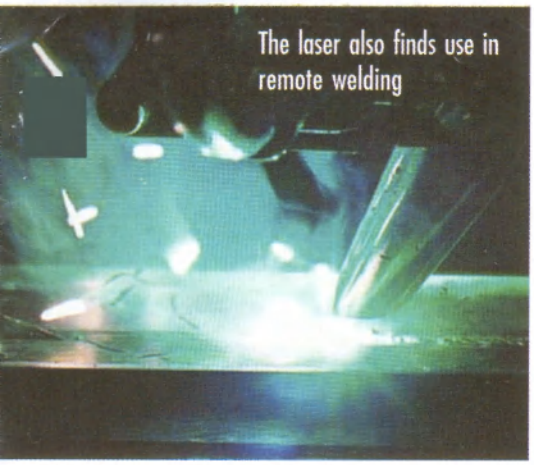
Laser in Fiction

Invisible rays that could be used as weapon were always imagined in fiction stories even before the principle of LASER was thought of. The author who popularized it as a "death ray" was H.G. Wells, who in his 1898 tale *The War of the Worlds* described it as an "inevitable, invisible sword of heat" that Martians use against the Earthlings.

In 1927, Alexey Tolstoy depicted a LASER-like device in his science fiction novel *The Hyperboloid of Engineer Garin*. Through the 1930s these predictions were well played in celluloid also. In his novel *Fatal Eggs*, Mikhail Bulgakov used it to create some "biological effects" on the target though it was shown as a beam of red light that emerges from an advanced microscope.

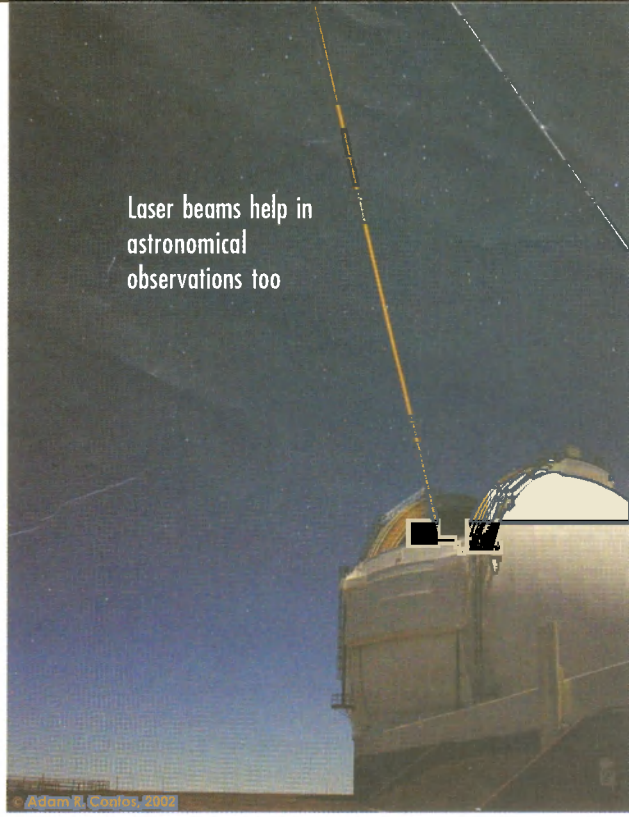
In the 1951 film *The Day the Earth Stood Still* LASER was the weapon the powerful robot uses. This was one of the reasons why newspapers first quoted Maiman's invention as "Death Ray" to his great dismay. In *Star Wars: Episode IV* also the doomsday fear was triggered using LASER. But, here it was not man but a distant star using LASER beams to destroy the Earth.





The laser also finds use in remote welding

In 1968, LASER proved to be a bloodless way to crush the kidney stone opening its potential towards guided surgeries. Now, it is routinely used to treat skin tumours as well as inaccessible brain tumours.



Laser beams help in astronomical observations too

© Adam K. Conlos, 2002

impossible to achieve this for a three-level energy system such as Ruby, whereas it could be much easier for a "four-level energy system".

Whether this was practically true or not was not the question but with repeated counseling against Ruby that came all along from respected scientists, Maiman's employer stopped funding his research. For Maiman it was not a discouragement as he was willing to spend from his own pocket, but the next hurdle was not much far.

The problem was the 'quantum efficiency' of Ruby, that is, the number of fluorescence-photons emitted for each light photon absorbed. In a much discussed paper published in the *Review of Scientific Instruments* (30, 995), Irwin Wieder, a scientist personally trained by Maiman, claimed that the quantum efficiency of Ruby was just 1%, not enough to attain a stimulated emission. And as per the calculations of Maiman, for a successful emission it should be 75%, an ardent but improbable objective!

However, there was a silver-line—if he could have a very bright pump of light source, it could work. And the 'eureka' moment came from reading an article about photographic-lamps that could achieve 'brightness temperature' of 8000 K. Everything that had to follow was more easy with the help of his technical assistant Irnee d' Haenens and on 16 May 1960 they got the first evidence of a LASER in action, the lifetime achievement of Maiman!

In the Limelight? No!

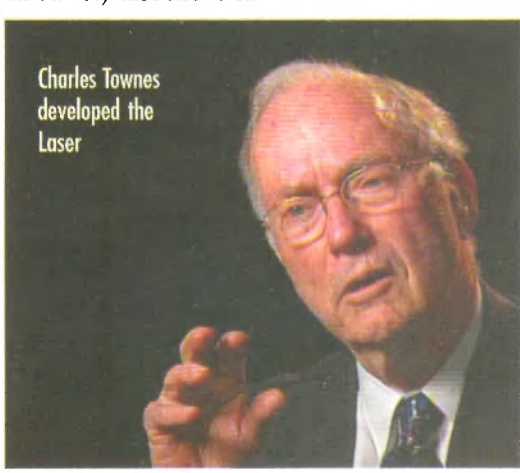
In the euphoric days that followed, Maiman tried to refine his equipment and immediately prepared a report of his exciting results submitting it to *Physical Review Letters* on 24 June 1960. However, the journal editor did not accept the paper, stating that the MASER-physics had already reached a mature state and "yet another MASER-paper" didn't deserve rapid publication. (No wonder, Maiman's invention was not 'LASER' then, it was only 'optical-MASER', as it was not Maiman but Gordon Gould, a graduate student at Colombia University who later named it as LASER.)

Anyway, Maiman had to pen a shorter version of his original article and send it to *Nature*, where it was accepted (187, 493). It was scheduled for the 6 August issue, but Hughes Lab was anxious to conduct a press conference before that—since Bell Labs was also involved in the race, there was no prize for a 'runner up'! Thus the world came to know about it on 7 July 1960, which erased the long held conviction that LASER is not practically a possible thing. But many still continued to (or liked to!) disbelieve it.

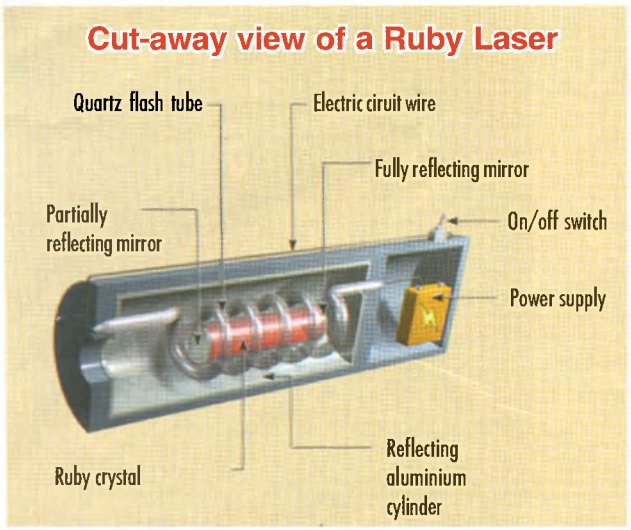
National Ignition Facility

The National Ignition Facility (NIF) located at California's Lawrence Livermore National Laboratory is the world's largest LASER. It covers 70,000 m^2 and contains 8000 large optical units, each up to 1 metre in diameter. Together, the facility's 192 LASER beams can provide 1.8 MJ of energy with a combined power of 500 TW (500 x 10^{12} W). This is about 40 times more than the power consumed by the entire world. Of course, this power only lasts for a few nano seconds, but it is enough to create pressures up to tens of millions of atmospheres, forcing atoms of Deuterium and Tritium to join together.





Charles Townes developed the Laser



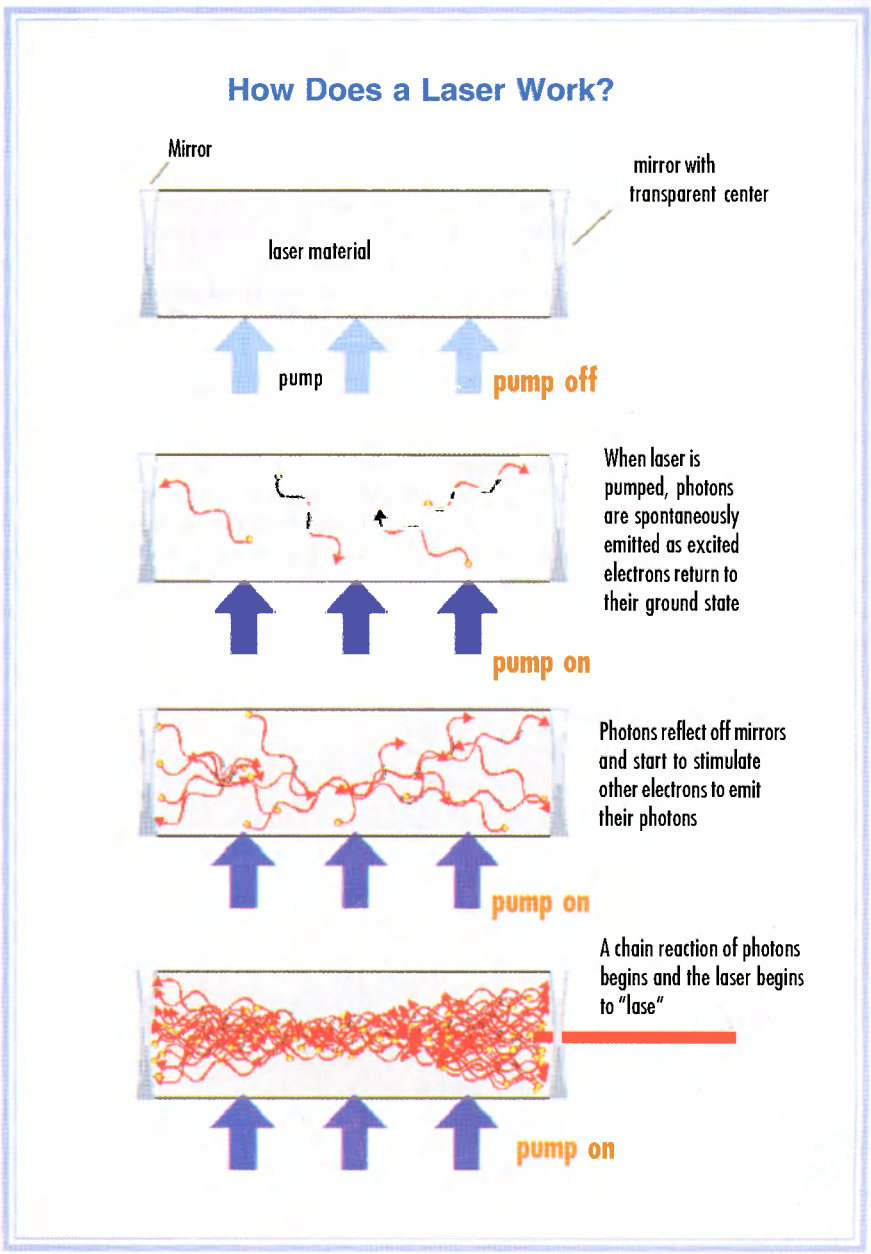


Though the potentialities of LASER were not known at that time, there was one more reason for Maiman not being in the limelight. On 1 August 1960, Shawlow and Townes at Bell Labs could reproduce Maiman's result and got it published also in the same journal that rejected Maiman's paper. It appeared in the October issue of *Physical Review Letters* and many who read it thought that Bell Laboratories was the first to build the LASER. For the American scientific circles as well as the public, Shawlow and Townes were familiar personalities and Bell Lab's trials on LASER implementation were rather well known also. So, even after 50 years, the invention of LASER still remains controversial, at least on the scoreboards of the rival fronts.

The LASER Revolution

The light of a LASER differs from that of an ordinary light source, just like music differs from noise. Moreover, a LASER beam can travel kilometers without much increase in its diameter. For example, when a Ruby-LASER was sent to Moon from Earth, the spot it created on the surface of Moon was only 9 km, even after travelling 2,40,000 miles.

Another quality of LASER is its immense luminous intensity. If we point our forefinger to sunlight, the power that falls on it is about one tenth of a watt. But, if light from LASER can be concentrated on it, it would be 10^9 watts. The size of a LASER device can be as big as a football field or as small as a pinhead. The light they emit can be invisible infrared, ultraviolet, X-ray



The wonder ray that made this possible was LASER, a brand new invention that had been demonstrated just nine years before, in 1960. It was the brainchild of a 32-year-old engineer-turned-physicist at Hughes Research Laboratories, Malibu, California.

Maiman: The Man of Laser

Theodore Harold Maiman was born in Los Angeles in 1927. In his teens, he earned money for college by repairing electrical appliances and radio. After studying at University of Colorado, he went to do graduate work at Stanford University and got PhD in Physics from there in 1955.

He was employed in industry initially as a researcher in Lockheed Aircraft where he studied communication problems linked with guided missiles. He then went to Hughes Research Laboratories, California to work on the MASER. He left Hughes in 1961 to join a venture called Quanatron where he became the president of the newly formed Korad Corporation. He formed Maiman Associates in 1968.

He was twice nominated for Nobel Prize, but it was Charles Townes who shared it with two Russian theorists in 1964. Maiman always felt that his role in LASER discovery was downplayed and he was hurt by it. It prompted him to write *"The Laser Odyssey"* a memoir, in which he tried to present his side of the story. He died on 5 May 2007 in Vancouver, Canada at the age of 80.



or all the colours of the rainbow.

The wavelength of some LASERs is tunable and their intensity can be amplified through several orders of magnitude. Some LASERs can't even emit enough energy to cook an egg, whereas certain others can vapourize steel! The pulse of a LASER can be as short as to last for a second (10^{-15}s) while some others can create continuous beams that will remain for decades to come. However, many of these potentialities came through many years of research and in the beginning many entrepreneurs found that there were very few possibilities for commercial exploitation of LASERs. Many companies couldn't even pursue definite applications from this field.

The next type of LASER that immediately followed Maiman's Ruby-LASER was the Helium-Neon-LASER developed by Bell Laboratories in the same year, 1960. But the first LASER that became the most prevalent type was the Diode-LASER made up of the semiconductor Gallium Arsenide. It soon mushroomed into a wide variety of commercial versions that still hold sway in the global market.

The first automated LASER scanning machine was used in a supermarket checkout-counter in Ohio in 1974 paving the way for a Universal Product Code (UPC). Called simply the 'bar-code', it is used billions of times everyday by retailers and manufactures worldwide today. In the late 1970s, the first transatlantic fibre-optic cables were laid down, which operated through diode-LASERs. They could deliver light into fibres with a few micrometers of core diameter, thus, connecting the world in an integral manner. The effect was a revolution in communication that swept through Europe and the US in the late 1980s.

In industry, there was yet another wonder that enabled metal cutting as easy as slicing a cake. It was the carbon dioxide-LASER that became a standardized cutting-tool even during the 1970s. In automobile industry, it introduced a new technique such as "remote welding" that made multiple spot welds possible through "optical steering".

This opened a new opportunity for LASER to be used as weapons though such fancies were already there with the development of Maiman's small LASER. But, rather than a "death ray", its first military application was for range finding. The first target LASER designators were used in the Vietnam War, in 1972. It made bombs intelligent rather than being stupid by falling anywhere. Ronald Reagan's 'Star Wars' programme envisaged LASERs as anti-missile weapons. Today these have become the norm for every country including India.

From the war-field the LASER directly entered into the music studio! In the 1970s, Sony and Philips began developing music digitally recorded on shiny plastic discs that were 12 cm in diameter, popularly known as "Compact Discs" (CDs). The first digitalized music album came out as a CD in 1982 with 74 minute of playback capacity – it was the album "52nd street" by Billy Joel. In the mid 1990s, came the Digital Video Discs (DVDs) that could store an entire feature length film. 'Blue-ray Discs' (BDs) were the next generation with 50-gigabyte capacity capable of holding more than five films in exceptionally high resolution.

Types of LASERs

There are many kinds of LASERs with different sub-types differing in their operational wavelength and applications.

I.	Gas LASERs: Helium-Neon LASER, Carbon dioxide LASER
II.	Chemical LASERs: Hydrogen Fluoride LASER
III.	Dye LASERs
IV.	Metal Vapour LASERs: Copper Vapour LASER, Gold Vapour LASER
V.	Solid state LASERs: Ruby LASER
VI.	Semiconductor LASERs: Hybrid silicon LASER, Diode LASER
VII.	Other types: Free Electron LASER, Raman LASER, Gas Dynamic LASER

TIMELINE OF LASER

1916	:	The theory of light emission by Albert Einstein—concept of stimulated emission
1951	:	Team led by Charles Townes builds the first MASER. Awarded Nobel Prize in 1964
1957	:	Gordon Gould coins the term 'LASER' in his lab notebook; basis for a 30-year patent dispute
1960	:	First working LASER invented by Theodore Maiman; Helium-Neon LASER comes from Bell Lab.
1961	:	First LASER surgery by Charles Campbell and Charles Koester
1962	:	Invention of diode-LASER by Robert Hall in General Electric Labs
1964	:	Kumar N. Patel at Bell Laboratories invents Carbondioxide LASER
1972	:	LASER target designators used for the first time in Vietnam War
1974	:	First trial of LASER barcode scanners in Supermarket
1978	:	First commercial LASER disc player in the market
1983	:	US President Ronald Reagan's Star War's speech reignites interest in LASER weapons
1988	:	TAT-8, the first transatlantic fibre-optic cable installed—dawn of LASER communications
1997	:	Creation of first "atom-LASER" by using Bose-Einstein condensate
2002	:	First LASER "guide star" used at the Keck 11 telescope in Hawai
2006	:	Blue-ray discs in market
2009	:	Charles Kao shares Nobel Prize for his work on Fibre Optics
2010	:	Word's largest LASER experiment at US National Ignition Facility aims to achieve "break-even point" for nuclear fusion

In fact, nobody could even imagine that Maiman's invention would become literally the workhorse of modern physics and so engraved on to everyday life. And today in its fiftieth birth anniversary, LASER is here to cool atoms, send data, mend eyes and trigger fusion.

Simultaneously, beam-scanning systems were inverted which could dynamically follow music and trace intricate patterns in space. The first spectacular event was at the "Expo 70" World Fair in Osaka, Japan. Rock concerts by bands like Pink Floyd usually employed them to evoke awe and surprise until restrictions came up due to safety reasons.

In the field of medicine also, LASER heralded an authentic revolution. The first medical use of LASER was in 1961, when doctors at Columbia University of Medical Center in New York destroyed a retinal tumour using a Ruby-LASER. Ophthalmology was the most benefited field where LASER was used for diagnosis as well as surgical cures. It enabled doctors to precisely vaporize a tissue or shape it as they wished. A classical example is LASIK (LASER-Assisted *in situ* Keratomileusis) Surgery where LASER is used to reshape the cornea. In 1968, LASER proved to be a bloodless way to crush the kidney stone opening its potential towards guided surgeries. Now, it is routinely used to treat skin tumours as well as inaccessible brain tumours.

New Dawns

In 1918 itself Einstein had predicted the existence of gravitational waves produced by moving masses. But until today it has not been directly detected. This is one of the research areas of future where LASER plays a part.

The equipment used for this is an Interferometer that was first built in 1978 though work on much powerful versions is still in progress. These are dubbed LIGO-LASER Interferometer Gravitationalwave Observatory of which one is in Hanford and the other in Livingston. Another is in Cascina in Italy officially known as VIRGO, which was opened in July 2003. Astrophysicists expect that LIGO and VIRGO may someday detect Einstein's dream waves.

LASERs also realized another of Einstein's predictions in 1924 about the existence of a special state of matter in which the so-called bosons may be forced to stay in a state with identical quantum properties. In 1995, that state was achieved which was called Bose-Einstein Condensation. With this, it was possible to explore certain aspects of quantum mechanics and superconductivity, the classical epitomes of modern physics.

Similar attempts have been made by the National Ignition Facility, California where conditions akin to the heart of a star have been created aiming to produce fusion power or the contrivances for it. The next generation telescopes also employ adaptive optics based on laser technology enabling astronomers to ascertain the position and movement of extrasolar planets.

Yes, in the LASER what we have is an 'Aladdin's Lantern'. What we need is only the imagination to order it tasks that we want done!

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Methuselah Gene

John Heinerman in his book on anti-ageing remedies narrates his interview with John Evans of Wales and Maudie Ryder of Salt Lake City, both of whom survived for more than 100 years. They attributed their long life to walking besides clean living and clean mind.

Ernst Mayr, one of the modern evolutionary biologists, was still working when he died in February 2005 at the age of 100. Bob Hope, the British born comedian who became an American icon, performed for 11 American presidents and maintained his keen sense of humour until his death in 2003, at the age of 100. Queen Elizabeth, the queen mother, died in 2002 at the age of 101.

Many more people have lived for more than 100 years. Scientists have been trying to discover the key to immortality since long. A group of Washington scientists has recently claimed to decode the genes that control ageing, a breakthrough that would help develop a drug to enable people live a healthy life for over 100 years. The report appeared in the April 1996 issue of *Science*.

This discovery opens the door to the fundamental understanding of why and how the human body ages. The discovery of what the Washington scientists call a Methuselah gene gives real weight to the belief that ageing is caused by DNA damage. The gene also plays a pivotal role by resisting the accumulation of genetic errors that are part of ageing. Why is the gene called Methuselah? According to biblical text, Noah's grandfather Methuselah lived to the age of 969. To honour this patriarch, scientists named the gene after him.

The researchers discovered that some people have a rare genetic mutation that decreases their cells' use of a growth hormone (insulin-like growth factor IGF-1). As a result, these people tend to be smaller and also live longer than the average life span. The size of many animals is also controlled by differences in their IGF-1 release with corresponding increase or decrease in life span.

Does this mean that shorter people live longer? Well, there are many other factors involved in determining the longevity of a person like genes, life style, birth weight, nutrition, vaccination, income level etc. than height alone. People born and raised under favourable conditions show substantially lower rates of chronic and fatal diseases later in life.

The secret of longevity probably lies in having the right set of genes, according to new studies of centenarians and their families. Such contributions are extremely rare, only one person in 10,000 reaches the age of 100. Centenarians appear to have a high chance of having several such genes embedded in their DNA.

Eline Slagboom of Leiden University, who studied 3500 Dutch nonagenarians, says that they have genes that stop those disease genes from being switched on. Longevity is strongly genetic and inherited. People who live to a great age metabolize fats and glucose differently, their skin ages more slowly and they have lower prevalence of heart disease, diabetes and hypertension.

Dr. Nir Barzilai of the Albert Einstein College of Medicine studied a group of 366 Ashkenazi Jews and their offspring and found that long-lived individuals possess a mutation of the ADIPOQ gene associated with high levels of protein called adiponectin. Higher levels of adiponectin were found in the blood of very aged persons than the younger ones. This was associated with healthy heart characteristics like higher level of HDL cholesterol, lower insulin resistance and lack of major risk factors like cardio-vascular disease and diabetes. They also found that the ADIPOQ gene was heritable.

Contributed by Dr. K. Venkataraman, Retd. Reader in Zoology, Madura College. Address: A-T-2, Porkudam Apartments, Bypass Road, Madurai-625010.

Miracle Plant

It is called the toothache plant, is added in food preparations for culinary purposes and has also proved effective in killing mosquitoes. *Spilanthes acmellis*, a member of the daisy family, but without the typical daisy-like petals. Native to the tropics of Brazil, it is grown as an ornamental (and occasionally as a medicinal) plant in various parts of the world.

The plant grows quickly and sends up bright yellow flowers 1cm in diameter, which form tight cones on short terminal stems. The yellow and brown cone-shaped flowers are actually a compact inflorescence composed of numerous tiny flowers. The inflorescence begins as a disk; the center expands upward as the individual flowers develop.

The most important taste-active molecules present are the alkamides, especially Spilanthol, which is responsible for the trigeminal and saliva-inducing effects of products such as Jambu oleoresin, a concentrated extract from Paracress. Besides, the main active ingredient spilanthol, *Acmella* also contains stigmasteryl-3-O-b-D-glucopyranoside and a mixture of triterpenes.

It is called the toothache plant because by chewing the leaves one can stop toothache instantly before rushing to the dentist. The flower heads are chewed to relieve the toothache and other mouth related troubles.

Spilanthes improves digestion, eases flatulence, improves the appetite, and helps to overcome nausea and vomiting by its stimulating effect on the salivary glands.

Leaves are also used externally in treatment of skin diseases. Root decoction is used as purgative. Leaf decoction is used as diuretic and lithotriptic. The whole plant is used in treatment of dysentery.

Global Warming Consequences for Coastal Life

Wetlands are important natural resources that play a distinct role in biodiversity conservation. They attract many primary and secondary consumers. More number of species aggregations of shorebirds with high population densities feeding in coastal beaches, mud flats, marshes and inland wetlands are commonly found during the migratory period.

The east coast of India, especially the Tamilnadu region, plays a significant role for shorebirds because many extensive wetlands are found there, including the Pichavaram mangroves and the swamps at Point Calimere (a Ramsar Site). Certain unprotected tidal flats found in the east coast also act as a stopover site for migratory birds.

Surveys (Pandiyan, 1999) in the Pazhaiyar tidal flat found 38 shorebird species. Subsequent surveys during 2000, 2001 & 2002 found 26, 23 and 21 species, respectively. However, the most recent bird census (November 2008 to 15 January 2009) in the same region has given shocking results—only six species have been recorded! These are Kentish plover *Charadrius alexandrinus*, Little ringed plover *Charadrius dubius*, Ringed plover *Charadrius hiataicula*, Common snipe *Gallinago gallinago*, Common sandpiper *Actitis hypoleucos* and Yellow wattled



The herb exhibits general immunomodulator properties when used internally, boosting production of leucocytes and anti-viral interferon as well as promoting phagocytosis. The root of this herb is used for premature ejaculation and rejuvenation. *Spilanthes acmella* is promoted as a sexual enhancer. Spilanthol has anesthetic and tickling properties, which produces excitation when applied in the female genitalia.

It also cures asthma, long cough, sore throat. In fungal infection and bacterial infection leaves are applied to the affected parts.

For culinary purposes, a small amount of shredded fresh leaves adds a unique flavour to salads. Cooked leaves lose their strong flavour and may be used as leafy greens. Both fresh and cooked leaves are used in dishes (such as stews) in parts of Brazil, often combined with chillies and garlic to add flavor and vitamins to other foods. A related species is used in several Southeast Asian dishes, such as salads. Consumption of portions or whole flowers has been reportedly used to offset the intense heat of chillies and peppers

Eating a whole flower bud results in a grassy taste, followed by an extremely strong tingling or numbing sensation and often excessive saliva production and a cooling sensation in the throat. These buds are known as Szechuan buttons, sansho buttons, and electric buttons. In India, the buds are used as flavoring in chewing tobacco.

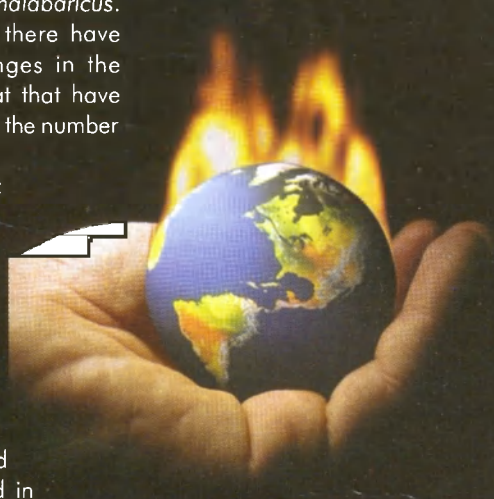
Extracts using hexane of freshly harvested flowers of *S. acmella* have also proved effective at killing mosquitos.

Contributed by Ms Shazia and Dr M.B. Siddiqui who are in the Department of Botany, Aligarh Muslim University, Aligarh-202002; Email: shazia.amu@gmail.com, zaman.amu@gmail.com

lapwing *Vanellus malabaricus*. Within ten years there have been rapid changes in the Pazhaiyar tidal flat that have drastically reduced the number of species.

Recent benthic sampling of five kilogramme of soil sample found just 2-5 chironomid larvae, whereas in earlier reports (Pandiyan 2002) 80-320 chironomid larvae were found in the same sample size. This indicated that availability of prey declined remarkably.

The recent survey also indicated a dramatic change in the tidal flat landscape. The tsunami during 2004 invaded about 3--4 km of the shore areas. Strong tidal waves of tsunami severely damaged the tidal plain and the landforms along the coast. Because of this changed habitat landscape and tidal rhythm, there are no river discharges into the mudflats except during heavy flood seasons.



It is possible to save a species when it is approaching the extinct stage by using conservation measures such as captive breeding, artificial breeding and cryopreservation. But losses and alterations of habitats due to natural disasters such as cyclone and tsunami are unavoidable and difficult to control. Hence, it is essential to find ways to overcome these problems using habitat management measures.

It is vital to assess the habitat loss and alterations as soon as possible after the natural disaster and restore the habitat to its natural shape by adopting management strategies such as removal of silt deposition, opening of closed estuary mouths, prevention of soil erosion, maintenance of fresh water discharge, etc. Elimination of weeds followed by closing of planting with indigenous grasses and over wood removal in areas colonized by weed is also necessary.

Early detection and rapid response to habitat loss and alterations could prevent loss of biodiversity.

Contributed by Dr Jeganathan Pandiyan, Dr Rajarethinavelu Nagarajan, Dr Subramanian Asokan and Dr Krishnamoorthy Thiyagesan of the Department of Zoology & Wildlife Biology, AVC College (Autonomous), Affiliated to Bharathidasan University, Mannampandal, Mayiladuthurai-609305, Tamilnadu; Email: dunlinpandiyan@gmail.com, dunlinpandiyan@rediffmail.com

Medicinal Kurchi

Its name tells it all. *Holarrhena antidysenterica* is a boon for those suffering from dysentery. Commonly called Bitter Oleander, Kurchi grows throughout India up to an altitude of 4,000 feet, with special abundance in the sub-Himalayan tract. It is commonly known as Connessi Bark, Kurchi Bark, Dysentry Rose Bay, Tellicherry Bark, and Coneru.. It is a deciduous shrub or a small tree. It has a rough, pale brownish or grayish bark.

Kurchi grows to a height of 12 to 24 ft and bears white aromatic flowers. There are certain varieties like white, black, sweet or bitter. Medicinally the black and bitter type has been found more effective.

The bark of the root is mainly employed. The seeds are also used medicinally, after being cleaned roasted and powdered.



Fruits of the tree known as Indrajava, have been used for centuries as medicine.

Kurchi has found an honorable place in modern pharmacopoeia as a boon for those suffering from dysentery. The powder of the bark is given with buttermilk. It stops the griping pain, reduces mucus thus facilitating clear motion. Grandmothers are known to give indrajava to children from their early days for troubles due to worms.

The bark is useful in treatment of piles and skin diseases. It is also indicated in diarrhoea, indigestion, flatulence, colic, amoebic dysentery and diarrhea. The seeds are used in treatment of fever and cold. Their powder is used in dressing oozing wounds. The bark of bitter oleander when grated in cow's milk helps in treating painful, difficult micturition and urinary stones. The herb has proven to be useful in treating rheumatoid arthritis and osteoporosis.

The principal alkaloid of the Conessi Tree is Connesine. There are around 30 alkaloids reported to be present in this herb, mostly in the bark. Conamine, conkurchine, connessimine, kurchine, conarrhinine, holarrhinene and isoconcessimine are few examples. Conessi has many medicinal properties. In 2004, the *Indian Journal of Experimental Biology* had reported the antibacterial and antidiarrhoeal agents of the plant. The antibacterial activity of *H. antidysenterica* against the enteric pathogens like *Vibrio cholerae*, species of Shigella, *Salmonella typhimurium*, *S. enteriditis*, Klebsiella spp, *Proteus mirabilis*, *E. coli*, *Staphylococcus aureus* and Pseudomonas etc. has been proved recently.

Contributed by Dr. Hafeezullah Baig, Assistant Director (drhafeezullahbaig@gmail.com), and Dr. Suryanarayana Y. (drsuryamd@gmail.com), Senior Research Fellow, Drug Standardisation Unit (H), Central Council for Research in Homoeopathy, O.U.B No.32, Osmania University, Hyderabad-500007

News Briefs

■ Some bacteria grow electrical hair that lets them link up in big biological circuits, according to a University of Southern California biophysicist and his collaborators. The finding suggests that microbial colonies may survive, communicate and share energy in part through electrically conducting hairs known as bacterial nanowires. A bacterial nanowire looks like a long hair sticking out of a microbe's body. Like human hair, it consists mostly of protein.

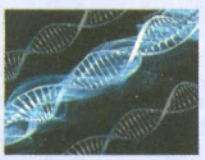
■ Researchers are using the bacteria as a viable option to make electricity. *In the microbial fuel cell, bacteria form a biofilm that is attached to the electrode by a sticky sugar and protein coated biofilm matrix. When grown without oxygen, the byproducts of bacterial metabolism of waste include carbon dioxide, electrons and hydrogen ions. Electrons thus produced are shuttled onto the electrode by the biofilm matrix, creating a thriving ecosystem called the biofilm anode and generating electricity.*



■ Scientists have shed light on how malaria is able to resist treatment with a leading drug. They have identified a gene that enables the parasite to resist treatment. Identification of this gene paves the way for further studies that could eventually help control the development of resistance to artemisinin and lead to more effective drugs for human malaria. The study used emerging technology that allows rapid identification of genes enabling the parasite to withstand existing drug treatments.



■ Take eight tiny DNA strands just 60 nucleotides long, combine with a master mix of enzymes and reagents, and incubate at 50°C for an hour. By following this simple recipe, researchers could synthesize the genome of a mouse mitochondrion in just five days. The technique gives synthetic biologists the simplest tool yet for designing and constructing gene sequences to make synthetic vaccines or pharmaceuticals, or to turn microbial cells into alternative energy sources.



■ A new type of snub-nosed monkey named *Rhinopithecus strykeri, with white-tufted ears and a white beard,* has been found in a remote forested region of northern Myanmar. Studies of a carcass and four skulls showed the monkey differed from snub-nosed monkeys in China and Vietnam. The scientists estimated there were between 260 and 330 of the monkeys living in an area of about 270 sq km (100 sq miles) and believed the species to be critically endangered. Monkeys were hunted for meat or fur and their body parts were used in traditional medicines in China.



■ A team of scientists has detected six isotopes, never seen before, of the superheavy elements 104 through 114. Starting with the creation of a new isotope of the yet-to-be-named element 114, the researchers observed successive emissions of alpha particles that yielded new isotopes of copernicium (element 112), darmstadtium (element 110), hassium (element 108), seaborgium (element 106), and rutherfordium (element 104). Rutherfordium ended the chain when it decayed by spontaneous fission.

HOLOGRAPHY

Lensless Technology of 3-D Imaging

P.K. MUKHERJEE and U.P. TYAGI

Holography technology finds use in innumerable fields with its applications being almost limitless.

WHAT is a photograph? Well, a photograph is basically the recording of the differing intensities of the light wave reflected by the object and imaged by a lens. But information about the dimensions of the object is contained not only in intensity (square of amplitude) but also in the phase of the light wave.

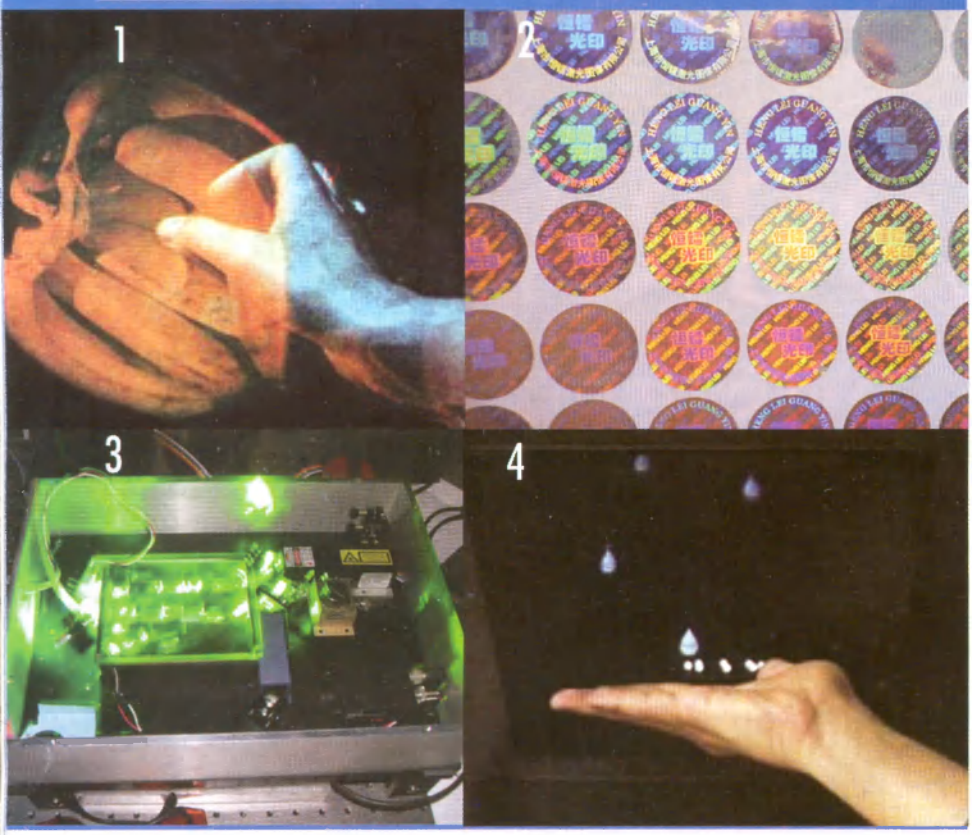
In fact, the phase attributes of the wave are necessary for our eyes to see depth. An ordinary photograph records only the intensity attributes of the wave; it loses the phase completely. That is the reason why an ordinary



Stephen Benton who invented the rainbow hologram (right); Denis Gabor (below)







(1) Holographic Bananas;
(2) Holographic stickers;
(3) Application of Dynamic Holography, a project that seeks to use light to probe chemical sensors as a means of smelling
(4) Researchers at the University of Tokyo are working to create holographic displays that mimic the sensation of interacting with solid objects. The researchers place a reflective marker on a person's hand and use Nintendo Wiimotes to track the position of the hand relative to the hologram. As the hand gets near the hologram, the display triggers a feedback mechanism, which feeds acoustic radiation pressure to the hand, creating the sensation that the person is touching an object. At the same time, the hologram reacts to the hand's position, and can be batted, grabbed, or floated based on the hand's position.

Recent development of atomic mirrors (especially ridged mirrors) has provided the tools necessary for the creation of atomic holograms.

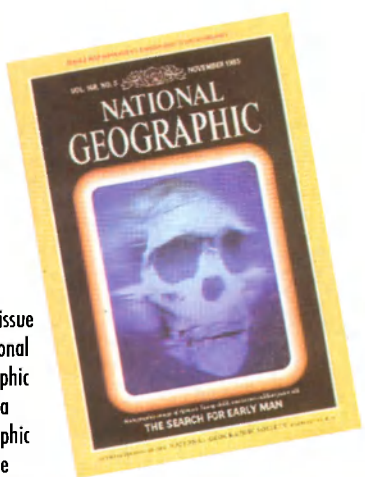
photograph gives a two dimensional (2-D) image. We have all grown accustomed to seeing the three-dimensional (3-D) world compressed into the flatness of a 2-D image in which the depth of the field is completely missing.

Strictly speaking, a normal photograph contains only one viewpoint of an object whereas in order to see depth our eyes need a minimum of two viewpoints. Each eye then records a slightly different viewpoint of an object. Our brain combines or blends the two and, thus, we are able to see depth. Such kind of vision using two viewpoints of an object is called stereoscopic vision.

However, the shortcoming of stereoscopic images is that when we move our head from side to side or up and down, we still only see the same two viewpoints whereas we should be seeing continuously changing viewpoints of the object. As a result, the image does not quite appear to be three-dimensional. In fact, to make a record of a three-dimensional (3-D) object, we need to record the continuous set of viewpoints of the object. This is done by using the principle of holography—a lensless technology of 3-D imaging.

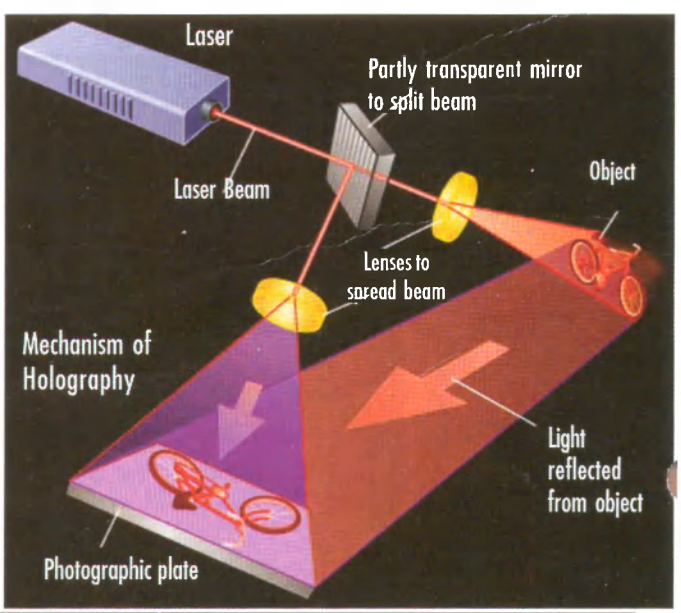
History of Holography

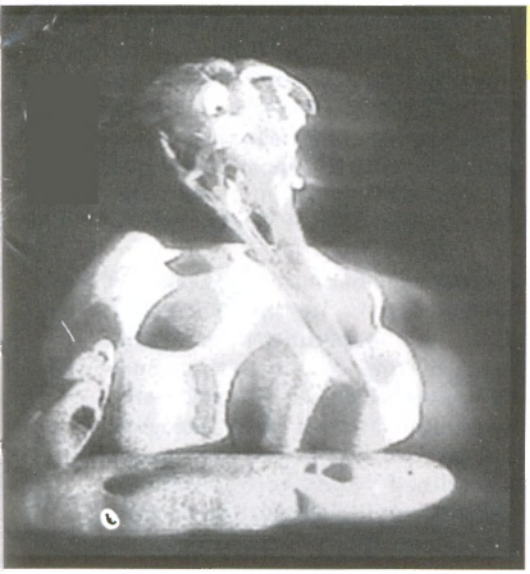
The technique of holography was developed by the British physicist



A 1985 issue of National Geographic with a holographic image

Unlike a photograph, a hologram is quite unintelligible and gives no idea about the image embedded in it. But, it contains information not only about the amplitude but also about the phase of the object wave.





"Skull and Rocks" by the artist holographer John Kaufman

Dennis Gabor (who was a native of Hungary) in 1947 while working in the Research Laboratory of the British Thomson–Houston company in Rugby, England. The invention won him the 1971 Nobel Prize in physics.

In fact, Gabor was working towards improving the resolution of the electron microscope, which was limited due to the poor performance of electron lenses. By looking into the problem in depth, he came up with a solution using a two–step lensless imaging process known as "wavefront reconstruction technique" or holography (from the Greek word *holos* meaning whole or complete and *grafe* meaning writing or drawing).

The holographic process involves creating interference between the light wave reflected by the object (called the object wave) and a background wave (called the reference wave). The background wave converts phase differences into intensity differences and the resulting interference pattern is recorded on a photographic plate. This record, called hologram, contains the entire information about the object, which can be viewed at a later time by illuminating the hologram with an appropriate light beam.

The British Thomson–Houston Company filed a patent for holographic technique developed by Gabor on 17 December 1947 and was granted the patent (GB 685286). It may be noted that the technique, as originally developed by Gabor, is still in vogue in electron microscopy where it is known as electron holography.

Although Gabor showed the applicability of the holographic technique to light waves by using a mercury discharge lamp, the real development in (optical) holography began only after T.H. Maiman invented (ruby) laser in 1960. In 1962, Emmett N. Leith and Juris Upatnieks, working in the Radar Laboratory of the University of Michigan, USA used the off-axis technique, borrowed from their work in the development of side–reading radar to develop the first "transmission hologram" of 3-D objects (toy train and bird). The off-axis technique was a modification of the original in-line technique employed by Gabor using the mercury discharge lamp that produced both the virtual and real images on the same axis.

The difficulty with Gabor's technique was that an observer focusing on one image always saw it accompanied by the out-of-focus twin image. This difficulty is overcome in the off-axis technique where the virtual and real images are angularly separate from each other and from the direct beam too. The off-axis technique developed by Leith and Upatnieks is still regarded as the staple of the holographic methodology.

The year 1962 also saw another development by Yuri Nikolayevich Denisyuk of Russia who introduced a scheme for generating holograms that was conceptually similar to the earlier colour photographic process of 1908 Nobel laureate Gabriel Lippmann. Denisyuk succeeded in producing a white–light reflection hologram, which, for the first time, could be viewed in light from an ordinary incandescent light bulb.

Another significant development in holography took place in 1969 when Stephen A. Benton of Palaroid Research Laboratories, Massachusetts, USA succeeded in creating white light holograms that could be viewed in ordinary white light. These holograms show all the seven colours constituting white light and are called "rainbow" or Benton holograms.

Benton's invention was indeed a breakthrough in the field of holography because it made mass production of holograms possible using an embossing technique. This involves 'printing' the hologram by stamping the interference pattern onto plastic, which can be duplicated millions of times at a very nominal cost.

Benton's technology attracted artists worldwide who adapted this to their work and in this way brought holography into public awareness. Benton's holograms are used on credit cards, magazines and other commercial products to prevent forgery. Also, these embossed holograms are now being extensively used by the publishing, advertising and banking industries.

In 1972, Lloyd Cross developed a technique that combined white light transmission holography with conventional cinematography. In this way he was able to develop integral holograms, called "integrams". Looking through a transparent cylindrical drum, the three-dimensional images can be seen in motion. Such holograms describing motion find applications especially in science fiction movies.

The year 2008 saw another technological breakthrough in the field of holography. Under the leadership of Tay Peyghambariam, optical scientists at the University of Arizona College Of Optical Sciences, working in collaboration with Nitto Denko Technical Corporation, Oceanside, California, USA, succeeded in making 3-D holographic displays that could be erased and re-written in a matter of minutes. Their device consisted of a special plastic film sandwiched between two pieces of glass each coated with a transparent electrode. In this device, the images are 'written' with the aid of laser beams and an externally applied electric field into the light sensitive plastic called 'photorefractive' polymer. The holographic displays in the new technique are capable of showing a new image every few minutes.

Principle of Holography

Holography is actually a two-step process that involves recording of the hologram and reconstruction of the image from the hologram. For recording the hologram, a highly coherent laser beam is divided by a beam splitter into two beams. One of these beams, known as the reference beam, hits the photographic plate

Holograms are often used as a plot device in science fiction movies. In *Total Recall*, the main character uses a device similar to a wristwatch to produce a hologram of himself to deceive his foes. *Star Trek: Voyager*, introduced the bizarre concept of Emergency Medical Hologram (EMH) doctor. In a recent highly popular science fiction movie *Avatar*, holographic displays were used extensively on terminals and HUDs.

directly. The other beam illuminates the object whose hologram is to be recorded. This gets reflected by the object. The reflected beam, called the object beam, falls on the photographic plate. The object beam and the reference beam are made to mix with each other to form the interference pattern on the photographic plate. The resulting interference pattern forms the hologram.

However, unlike a photograph, a hologram is quite unintelligible and gives no idea about the image embedded in it. But, it contains information not only about the amplitude but also about the phase of the object wave. It has, therefore, all the information about the object.

For viewing the image, the hologram is illuminated with another beam, called the read-out or reconstruction beam. In most cases, this beam is identical with the reference beam used during the formation of hologram. This process is termed as reconstruction.

The interference pattern (in the developed photographic plate) or hologram acts as a diffraction grating (a structure with a repeating pattern e.g. a metal plate with slits cut at regular intervals). The waves diffracted through the hologram carry the amplitudes and phases of the waves originally diffracted from the object during the formation of the hologram. In this way the reconstructed image is obtained.

To get a high quality hologram, light beam of high coherence is needed. Generally, the helium-neon gas laser, which gives highly coherent and continuous output beam, is used for this purpose. Sometimes, high power pulses from a laser like ruby laser are also used. The holograms are recorded on special photographic plates, which are of very high resolution and record very fine interference fringes. The plate is developed and fixed (processed) in the usual way.

There is a kind of magic about the hologram, which is often called a window with a memory. With naked eye, it does not give any picture of the object. The viewer is able to see only an exposed negative with grayish random patterns on the surface. However, when the hologram is positioned in its holder and viewed in a monochromatic light beam, such as that produced by laser, the random patterns are transformed into a sharp and detailed three-dimensional image of the object. The image looks like a solid object hanging in space in three dimensions irrespective of the viewer changing his angle of view by moving his head from side to side or up and down.

Instead of a conventional photographic plate, holograms can also be recorded by using a digital device e.g. a charge-coupled device (C.C.D.) camera. Known as digital holography, the reconstruction process in this case can be carried out by digital processing of the recorded hologram using a standard computer. A three-dimensional image of the object can later be visualized on a computer screen or TV set.

Applications of Holography

Holography finds application in many diverse fields.

Data Storage: An important application of holography is in the field of information or data storage. The ability to store large amounts of information in some kind of media is of great importance as many electronic products incorporate storage devices. The advantage of holographic data storage is that the entire volume of recording media is used instead of just the surface. In 2005, holographic versatile disk (HVD), a 120 mm disk that used a holographic layer to store data, was produced by some companies. This had the potential of storing 3.9 TB (terabyte) data. Further developments in the field are going on and it is expected that holographic data storage would become the next generation of popular storage media.

Security: Another major application of holography is in the coding of information for security purposes and in preventing counterfeiting. Such holograms, called security holograms, are replicated from a master hologram that requires very expensive, specialized and technologically advanced equipment, such as electron-beam lithography system. This kind of technique allows creation of surface holograms with a resolution of up to 0.1micrometre.

The security holograms are widely used in many currency notes. Security holograms in multiple-colour are created with several layers. They are used in the form of stickers on credit and bankcards, books, DVDs, mobile phone batteries, sports equipments, branded merchandise etc.

Cryptography: Holographic methods may also be used in cryptography for secret communication of information. This is done by recording the holograms of secret documents, maps and objects. The images can be reconstructed at the receiver end.

Holographic Microscopy: Holographic microscopy is yet another potential application of holography. A conventional microscope has a small depth of field (the range of depth over which an object is in focus at any microscopic setting). Biological specimen, generally suspended in a fluid, move about making them sometimes in and sometimes out of focus of the microscope. However, this motion can be "freezed" in a hologram taken through a microscope. The reconstructed 3-D image can then be studied at leisure.

Holographic Interferometry: One of the most promising applications of holography lies in the field of interferometry. It was a chance discovery by a number of groups working around the world. In the year 1965, R.L. Powell and K.A. Stetson,

Haines and Hildebrand, and G.W. Stroke and A. Lebeyrie, all from the University of Michigan, and Ann Arbor and J.M. Burch from England simultaneously but independently discovered holographic interferometry. They found that the holographic images of vibratory (or moving) objects got washed out. However, if double exposure were used, first with the object at rest and then in vibration, interference fringes would appear. These fringes are characteristic of the stresses and strains suffered by the body; hence they can be used for testing stresses, strains and deformations of objects under the effect of mechanical stress or thermal gradient.

Holographic interferometry can also be used for studying vibrations in objects. This has been used to study the vibration modes of both string and percussion musical instruments. The technique can also be applied for non-destructive testing of materials, to detect cracks, disorders, voids and residual stresses in a test sample without destruction of the sample. Holographic interferometry can be used for testing automobile engines, aircraft tyres, artificial bones and joints.

Medical Applications

Some of the prominent fields of medical science in which holographic technique is used include endoscopy, dentistry, urology, ophthalmology, otology, orthopaedics and pathology.

In the field of ophthalmology any retinal detachment or intraocular foreign body can easily be detected. In corneal surgery, holographic technique can be used for measurement of elastic expansion of the cornea, which is a very vital information for the surgery. Holographic lenses can make one lens provide several different functions, such as correcting regular vision and also acting as magnifiers for reading, all in the same lens and throughout the entire lens at the same time.

Endoscopic holography, which combines the features of holography and endoscopy, provides a powerful tool for non-contact high-resolution 3-D imaging and non-destructive measurements for natural cavities found inside the human body or any difficult-to-access environment.

In otology, different parts of the human peripheral hearing organs are studied using double exposure and time–average holographic interferometric techniques.

In urology, holographic techniques can be used for detecting kidney stones and for the diagnosis of other urinary problems e.g. tumors in the urinary bladder.

For applications of holography in dentistry both continuous wave and pulse laser holography have been used. Besides other applications in dentistry, holograms can be employed as training aids in the disciplines of dental anatomy and operative dentistry.

In otology, different parts of the human peripheral hearing organs are studied using double exposure and time–average holographic interferometric techniques.

Other Applications

The holographic technique can also be used for making high quality gratings that are used with precision optical instruments.

Holography has also been used as a powerful display tool. Holograms find important applications in museums, aquariums, drawing rooms, display windows and laboratories. A new class of artists, called holography artists or holographers, has emerged. They use holography to express their creativity and create holograms of unparalleled beauty and essence that are displayed in galleries around the world.

Holographic optical elements (HOEs) are used in heads-up displays (HUDs) in airplane cockpits. They allow pilots to keep their eyes on the sky or runway while still being able to read their instrumentation, which appears to float in front of their cockpit window. This feature is available as an option on several automobiles too.

Holography is also used for determining the three-dimensional size of a package in post offices, large shipping firms and automated conveyor systems. A holographic scanner is used for this purpose.

Holograms are often used as a plot device in science fiction movies. In *Total Recall*, the main character uses a device similar to a wristwatch to produce a hologram of himself to deceive his foes. *Star Trek: Voyager*, a foreign television series introduced the bizarre concept of Emergency Medical Hologram (EMH) doctor. In a recent highly popular science fiction movie *Avatar*, holographic displays were used extensively on terminals and HUDs.

Holography has various non-optical applications as well. Electron holography, originally invented by Dennis Gabor, to improve the resolution of electron microscopes, is the application of holography technique to electron waves rather than light waves.

Acoustic holography is a method used to estimate the sound field near a source. This is done by measuring acoustic parameters away from the source via an array of pressure and/or particle velocity transducers. The measuring techniques involved in acoustic holography are becoming increasingly popular especially in the field of transportation, vehicle and aircraft design. The general idea of acoustic holography has led to different versions such as near–field acoustic holography (NAH) and statistically optimal near–field acoustic holography (SONAH).

Developments in the field of physics (and applications) of atomic beams gave rise to another non-optical variety of holography called atomic holography. Recent development of atomic mirrors (especially ridged mirrors) has provided the tools necessary for the creation of atomic holograms. However, such holograms have not yet been commercialized.

Next in line are holographic television and motion pictures. It could be truly said that the promise for holographic technology is indeed limitless.

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T.V. VENKATESWARAN

Tales from our Grandma – Ardi

Here's an exciting story of the unraveling of a 4.4-million-year-old skeleton of what could be our great great great...grandmother!

HAVE you met your grandma? Most of us would have. Great grand ma—well, may be some of us. How about great great grand ma? Surely not. How about meeting your great great great... grand mother, about 2,00,000 generations ago?

Welcome to Ethiopia, say hi to Ardi. Perhaps, this 4.4-million-year-old skeleton of a hominid (belonging to the human family), excavated some time back is the mother of all humans. She is very short – just 4 feet tall. She is also frail – just 50 kg in weight.

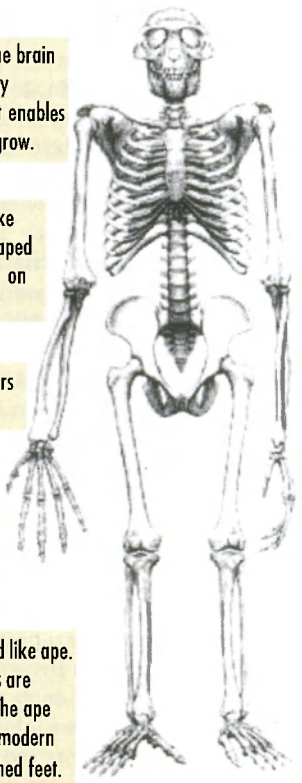
What tales can this 4.4-million-year-old grandmother tell us? It seems quite a lot; she can tell us about our evolution—how we became humans.

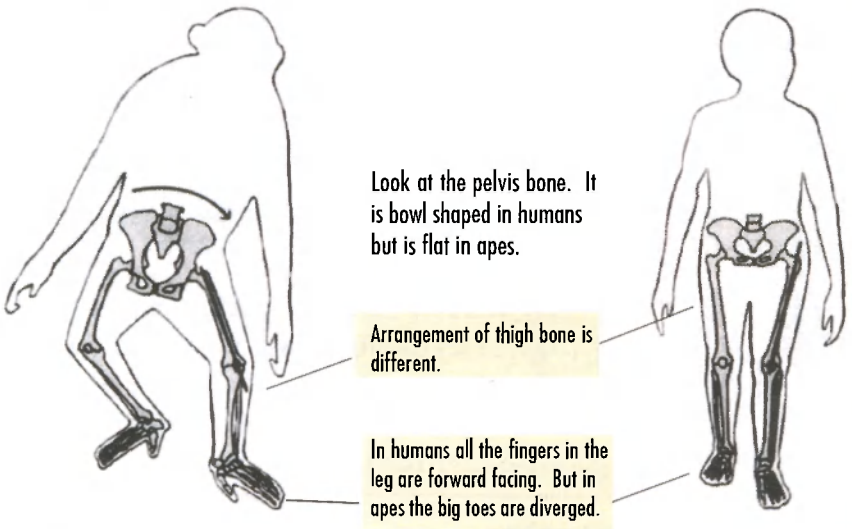
Ardi and her type of our ancestors have been named Ardipithecus ramidus – in Afar language ardi, meaning "ground" or "floor", and ramid, meaning "root" implying that this species is at the root of human evolution and it largely dwells on ground rather than on trees.

Of course, she is not flesh and blood. In fact, she is just a collection of 125 skeletons that researchers have unearthed from Afar valley in Ethiopia. It is not as if they got all the bones – they got about 45% of the skeleton but crucially there were skull, teeth, hand, leg, pelvis and even ribcage bones. This was adequate to understand how that hominid (ancient human) looked, how it moved, what it ate and so on. When they got all the bones and assembled it into a skeleton, they named her Ardi, short for Ardipithicus—the species to which she belongs. So she is Ardi...our great great... grandmother.

One important tale that this grand old ma tells us is that she can walk. So what? Anyone with legs can indeed walk. The point scientists are excited about is that Ardi could walk on two legs – that is, she was bipedal. What is the significance of walking on two legs or being bipedal? Walking on two legs, scientists believe, kick started encephalization—that is, increase in the size of the brain. Modern human – *Homo sapien sapiens* – have about 1500 cc of brain mass, whereas our ancestors had just about 450 cc. Legs and brains – chalk and cheese – isn't it?

The skull of an animal is supported by the spine. The hole in the skull where the spine inserts into the braincase is called 'foramen magnum'. In most animals that walk on four legs, the foramen magnum is at the back of the skull, which makes a certain kind of intuitive sense. The spine and skull are fixed horizontally and hence the spine projects well inside the skull taking up precious skull space.





What tales can this 4.4-million-year-old grandmother tell us? It seems, quite a lot; she can tell us about our evolution—how we became humans. The excavation and reconstruction of Ardi's bones took more than 15 long years.

On the other hand, in humans, the foramen magnum is tucked under the head so that the head is right on top of our vertical spinal column. The spine is at the bottom and it meets the skull at a 90-degree angle. What is the ultimate result of these two anatomies? Simply put, in four-legged animals more space is consumed by the spine and mussels needed for skull attachment, as they are horizontally aligned. But in bipedal humans, less space is devoted to the fitting. More space is available inside the skull for the brain to grow. As our ancestors stood up, their brain size also began to grow. Hence, walking on two legs is a crucial stage in the evolutionary history of humans. This means Ardi made the first baby step towards human evolution. That is why scientists are so excited about it.

Well, Ardi walked is important. But how do we know she walked? If we take a careful look at her bones three features seem to indicate that she walked. We know that the pelvis bone is what holds our upper body. In the human skeleton, the pelvis bone looks like a bowl. After all it has to 'hold' the upper body. But in apes, our close evolutionary relatives, the pelvis bone is like a sheet and not a bowl. Apes walk on four legs and the pelvis bone is vertically aligned and it does not have to hold anything. When researchers looked carefully at the pelvis of Ardi, it was found to be bowl shaped, not as much as modern humans, but still shaped like a cup. Moreover the scientists could make out that the skeleton belonged to a woman by looking at the pelvis bone. Pelvis of men and women are slightly different, as women have to give birth to children.

The thighbone is called femur. Ardi's thighbone was oriented to meet the knee-joint at an angle very similar to modern humans. In Apes the angle is outward such that it enables them to easily knuckle walk.

Take a quick look at yourself and you will find that our feet are rigid but palms are dexterous. This is because of a crucial bone in the leg called *os peroneum*, which is not present in our hands. Further in our feet all the fingers are aligned forward, unlike the palm where fingers can move in different directions. Our feet are rigid and fingers are facing forward so that we can walk, jump, run and so on on two legs. But in apes, the feet are just another pair of hands. The big toes of apes are diverged. Apes do not have *os peroneum*, so their feet are not rigid and it helps them to hold branches even with their feet when they move through trees. In Ardi, scientists found that the feet were rigid, it had *os peroneum* but surprisingly it had opposable thumb – a mixture of modern human and ape. Ardi's foot could grab branches and she could also walk efficiently.

What about the foramen magnum hole? Reconstruction of Ardi's skeleton shows that the hole was sort of under her skull like ours, just slightly farther back. Well, it implies Ardi was an upright animal and not a knuckle walker.

But why are we surprised? If we modern humans walk on two legs, then some time in the past our ancestors should have begun to walk on two legs. So what is the big deal? Apes are genetically closer to us and hence Apes and humans should have evolved from some common ancestor. How would have this common ancestor looked like?

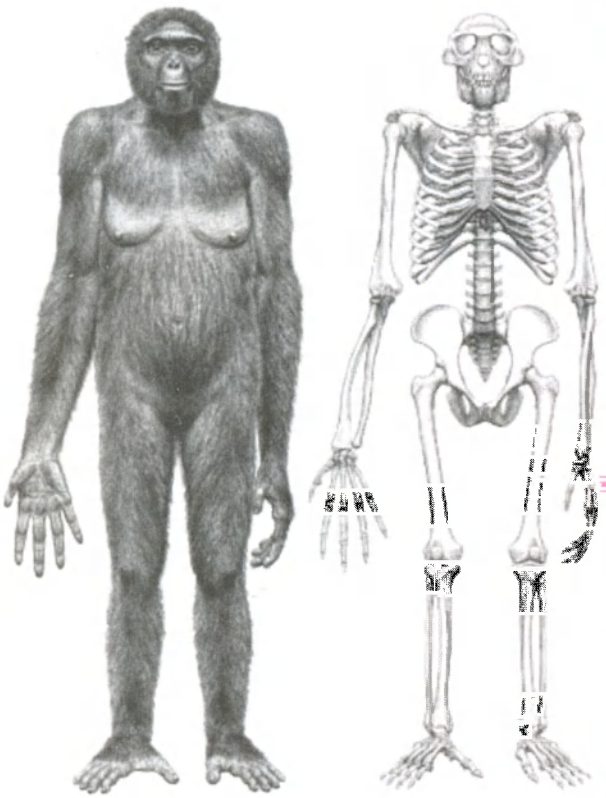
Until now we thought that this common ancestor would have traits of apes – may be not all, but still the main features of apes, which hitherto we considered primitive. Two distinct species would have diverged from this common ancestor – one becoming modern day apes – largely retaining the primitive traits, the second evolving to become humans. In other words we had conceived that apes evolved conservatively – without much change, whereas humans evolved new

Where Did Ardi Live?

Along with Ardi, in the same geological layer, hence belonging to the same time period, researchers were able to excavate 15000 fossils of animals and plants. Based on these fossils scientists were able to get a remarkably clear picture of the habitat Ardi roamed some 200,000 generations ago.

It was a grassy woodland with patches of denser forest and freshwater springs. Colobus monkeys chattered in the trees, while baboons, elephants, spiral-horned antelopes and hyenas roamed the terrain. Shrews, hares, porcupines and small carnivores scuttled in the underbrush. There were an assortment of bats and at least 29 species of birds, including peacocks, doves, lovebirds, swifts and owls.

Buried in the sediments were hackberry seeds, fossilized palm wood and traces of pollen from fig trees, whose fruit perhaps our grand ma Ardi relished.



Rare Feat

Excavation of near total skeleton, such as Ardi is rare, especially when we look for fossils of early hominids of 2 million years and older. Usually what we are able to excavate is just a piece of skull, or leg bone or jaw with few teeth intact. Before Ardi, we had Lucy, again a female specimen of a latter day hominid – 3.2-million-year-old fossil of *Australopithecus afarensis* –discovered in Africa. Lucy was also a spectacularly near complete skeleton. In most discoveries scientists were able to find only a piece of skull, or thighbone or a set of teeth.

It took many years for the scientists to reconstruct the skeleton. Once they had found which bone went where, they could use the actual bones and make the skeleton. The skeleton is now housed in the National Museum of Ethiopia in Adidas Ababa.

This 4.4-million-year-old skeleton of a hominid is mother of all humans. She is very short – just 4 feet tall and just 50 kg in weight.

traits. Until now we had thought that modern day apes have not changed much from the last common ancestor, but we humans have evolved radically. Ardi demolishes this assumption.

Indeed there is no certainty that Ardi and her comrades are the last common ancestors of humans and apes. Irrespective of whether Ardi is the last common ancestor or not, many of its main features should have been common between ancestral apes and human ancestors. For one, the presence of *os peroneum* in Ardi, which means when apes evolved they lost this bone in evolution so that they could move efficiently in the trees, whereas in humans the bone remained. That is, on this count, it is humans who have evolved 'less' as compared to apes.

Then, Ardi had opposable big toe in the leg, so do apes, but not humans. So the human big toe in the feet changed and aligned with the rest of the four fingers, whereas in apes this feature was retained. In like manner, Ardi's hand fingers are curved, a suitable anatomy for grasping the tree branch just like apes. In modern humans the fingers on our hand are largely straight which enables us to hold tools and do many jobs with our hands. Ardi's discovery changes our perception. So with this new knowledge we have to say that both modern humans and modern apes have evolved as much as each other; only what features evolved differed. This came as a surprise.

The excavation and reconstruction of Ardi's bones took more than 15 long years. The first bones of Ardi, finger bones, were chanced upon by a young Ethiopian student Yohannes Haile-Selassie on 5 November 1994. He and his fellow researchers carefully excavated the site. They found a part of the skull. They were excited. Then they found teeth—they were thrilled. Then they got leg bones – they were now really ecstatic. And they kept on finding more bone fragments – 125 of them. This accounted for 45% of the total skeleton. Well that is ok, if you have the right hand you can guess about the left one ... so they went about reconstructing it.

Tweaking the bones from the mud was not that easy. You cannot just dig with a shovel or hoe. The bones, 4.4-million-years-old would be fragile. In fact they turned to dust with even a gentle touch. With knives, the scientists carefully removed the sedimentary rock that held the bone fragments. The rock was then taken to a lab. In the lab the rock was placed under a microscope and using needles the mud and sand was removed! Fragment by fragment they recovered the bones. It took about three years for them to recover all the bones.

Now you have to assemble the bone fragments to reconstruct the skull or pelvis or the hand. It was like a giant jigsaw puzzle. You cannot again just assemble them. First of all they were so fragile it would have been difficult. Also how can you guess which fragment went where. So they took CT scan photographs. CT scan is like an X-ray picture. You put this picture in a computer where you can move the picture of one fragment near another and see if it fits. It was like a child playing with a jigsaw puzzle trying to fit the pieces to uncover the hidden picture.

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This is not one man's job. More than 80 scientists from 10 different countries participated in the excavation and reconstruction. It took 15 years and finally on 1 October 2009 they revealed Ardi to the world.

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DR. SUNITA CHAND &
DR. RAMESH CHANDRA PARIDA

Millennium Prize for Perelman

A look at the pathbreaking work of the eccentric mathematical genius Grigory Perelman who solved the 106-year-old Poincare Conjecture and who was recently nominated for the David Perelman Award.

NON-inclusion of mathematics in the list of the Nobel Prizes has been intriguing many since its very inception. People wonder how Alfred forgot about the mother of physical sciences while conceiving the idea of recognizing the best scientific talents for their contributions to the welfare of mankind. However, now prizes instituted for mathematics equal the Nobel in recognition. Perhaps the foremost are the Millennium Prizes of the Clay Mathematics Institute (CMI). Recently, the eccentric Russian mathematics genius Dr. Grigory Perelman has been nominated for this honour for solving the 106-year old Poincare conjecture.

The Millennium Prizes were conceived to honour outstanding mathematicians for solving some of the most difficult problems in mathematics, which eluded solution at the turn of the second millennium. Seven such problems were identified by the Clay Mathematics Institute (CMI) in 2000, which included the Poincare conjecture. These prizes are not meant to be awarded regularly every year like the Abel Prize or the Nobel Prizes. Only when some one solves one of the identified problems, he or she can be nominated for the honour. Therefore, the maximum number of the Millennium Prizes that can be awarded is limited to seven only. That's the reason why it took almost a decade to find a befitting nominee for this award.

Poincare Conjecture

In 1904, the French Mathematician Henri Poincare posed an epoch making question in one of his papers, which asked, "If a three-dimensional shape is simply connected, is it homeomorphic to the three dimensional sphere?" The statement can be explained by considering the analogous two-dimensional situation.



Henri Poincare

Let us think of a rubber band stretched around the spherical surface of an apple. It is easily seen that it can be shrunk to a point by moving it slowly, without tearing it and without allowing it to leave the surface. On the other hand, let us replace the apple by a doughnut, which is a torus. The band cannot be shrunk in anyway to a point without tearing it or the doughnut. It can be stated mathematically that the apple is "simply connected", whereas, the doughnut is not.

In 2006, Perelman created a ripple in the community of mathematicians by rejecting the coveted Fields Medal, considered to be the Nobel Prize equivalent in mathematics. This time also he has refused to accept the Millennium Prize, in spite of the worldwide appeal from various quarters and persuasion of a team of distinguished mathematicians

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In order to characterize the spherical surface of the apple, we can imagine a disc lying in a two-dimensional plane with its boundary lifted up and tied to a single point. In other words, it can be said that all the points are identified to a single point. It can be done if the two-dimensional disc is lying in a three-dimensional space i.e. we have a two-dimensional sphere in a three-dimensional space. Therefore, Poincare asked, if a two-dimensional sphere is characterized by the property of simple connectivity, a similar characteristic is valid for all closed three-dimensional objects embedded in a four-dimensional space, which are like three-dimensional spheres.

Although analogous results were found to be true at higher dimensions, the case of three-dimensional sphere had been proving to be the hardest. That is why, the question had been viewed as extraordinarily difficult and for long mathematicians were struggling to find an answer to it. Recently, Grigori Perelman succeeded in finding an answer.

Towards the Resolution

In fact, over the years, many outstanding mathematicians, including Poincare himself pondered over the problem. Of course, these led to the creation of new vistas in mathematics, but the conjecture still remained unsolved. For example, in 1961 Stephen Smale of the University of California, Berkeley proved that the analogue of the Poincare conjecture was true for spheres of five or more dimensions. However, it did not answer the original question of Poincare. On the other hand, it suggested that the theory of dimensions three and four was unlike the theory of spheres in higher dimensions. Then, a decade later, Michael Freeman of the University of California, San Diego announced a proof of the Poincare conjecture in dimension four, which could not be extended to dimension three. However, for their work Smale and Freeman were awarded the prestigious Fields Medal in 1966 and 1986 respectively.

Thereafter, three major developments took place in this field, which played crucial roles in guiding Perelman to reach the solution of the conjecture. These were, (i) William Thurston's geometrization conjecture, (ii) Aleksandrov limits of (geometric) spaces, and (iii) Ricci flow equation.

According to the geometrization conjecture, three-dimensional shapes could be broken down into pieces governed by one of the eight geometrics – a similar way as a molecule can be broken down into simpler atoms.

The ideas of limits of space deals with how one can take limits of geometric shapes, just as we take limits in calculus. To understand this, think of Zeno's paradox: First you walk half the distance from where you are standing, towards the wall of a room. Then you walk half of the remaining distance and go on repeating it. Every time you get closer to the wall, which is your "Limiting position", but you never reach it in a finite number of steps.

Again let us imagine a Y-shaped rubber tube collapsing with time. As time increases, its diameter gets smaller and smaller. Ultimately, as it becomes zero, the tube becomes an infinitely thin wire. The point where the arms of Y meet is different from others. It is called the "singular point" or "singularity" of this space. The kinds of shapes that occur as limits are called Aleksandrov limits of spaces, named after the Russian mathematician, who initiated and developed the theories.

The third development was connected with differential equations involving the rates of change in the two unknown quantities of the equation. Those were applied to geometric and topological problems as well as to physical ones. The differential equation that played a key role in solving Poincare conjecture is the Ricci flow equation. It was discovered twice – once for its application in geometry (mathematics) in 1982 and again in quantum field theory (physics).

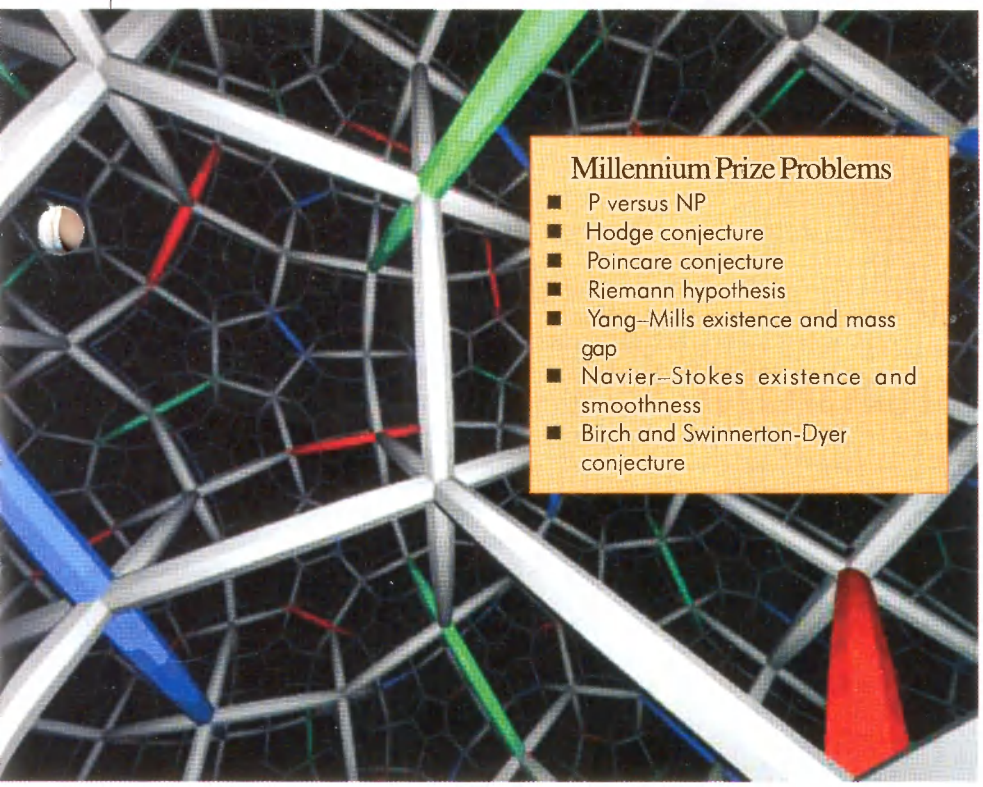
Ricci Flow Equation

In geometric context, the Ricci flow equation was the analogue of Fourier's heat equation. Just as the latter disperses temperature, the former disperses curvature. Therefore, even if a shape is irregular and distorted, Ricci flow can remove these anomalies, resulting in a very regular shape, whose topological nature is evident.

Richard Hamilton, in 1982, showed that for positively curved, simply connected shapes of dimension three, the Ricci flow transformed the shape into one that was even more like the round three-sphere, which in the long run became almost indistinguishable from this perfect, ideal shape. On the other hand, when the curvature was not strictly positive, solutions of the Ricci flow equation behaved in a more complicated manner, as it was non-linear. As a result, certain parts of the shape may be evolved towards a smoother and more regular state, while the other parts might develop singularities. Although this behavior posed serious difficulties, it also held promise. It was conceivable from it that the formation of singularities could reveal Thurston's decomposition of a shape into its constituent geometric atoms.

In 1999, Richard Hamilton published a paper showing that in a Ricci flow, the curvature was pushed towards the positive near a singularity. In it he made use of the collapsing theory. Again the Hamilton-Harnack inequality also played an important role in Perelman's proof. It was generalized to positive Ricci flow for positive solutions of Fourier's heat equation.

Although Hamilton established Ricci flow equation as a tool to resolve both conjectures and geometric problems, obstacles still remained to a proof of Poincare conjecture. One of those was the lack of understanding of the formation of singularities in Ricci flow, akin to the formation of blackholes in the evolution of the cosmos. At last, in 2002 and 2003 Grigory Perelman found a solution not



Millennium Prize Problems

- P versus NP
- Hodge conjecture
- Poincare conjecture
- Riemann hypothesis
- Yang–Mills existence and mass gap
- Navier–Stokes existence and smoothness
- Birch and Swinnerton-Dyer conjecture

The Millennium Prizes were conceived to honour outstanding mathematicians for solving some of the most difficult problems in mathematics, which eluded solution at the turn of the second millennium.



Grigory Perelman

only to the Poincare conjecture but also to Thurston's geometrization conjecture.

Perelman's Proof

Perelman's method of proof was based on the theory of Ricci flow. To its application in topology, he brought great technical virtuosity as well as new ideas. One of those was combination of collapsing theory in Riemannian geometry with Ricci flow. It gave an understanding of the parts of the shape that were collapsing on to a lower-dimensional space.

Similarly, another was the introduction of entropy. While in the classical theory of heat exchange, it measures disorder in atomic level, here it means disorder in global geometry of space. Perelman's entropy, like the thermodynamic entropy, is increasing with time and there is no turning back. Using his entropy function and a related version, Perelman was able to understand the nature of singularities that formed under Ricci flow. There were just a few kinds and one could write down simple models of their formation.

Then it became clear how to cut out the parts of the shape near them as to continue the Ricci flow past the times, at which they would otherwise form. From these results, Perelman showed that the formation of singularities could not run into Zeno's wall; for example, imagine a singularity that occurs after one second, then after half a second more, then after a quarter second more and so on. If this were to occur, the "wall", which one would reach two seconds after departure, would correspond to a time at which Ricci flow would cease to hold. The proof would be unattainable. However, with this new mathematics in hand, it was attainable.

In 2006, Perelman created a ripple in the community of mathematicians by rejecting the coveted Fields Medal, considered to be the Nobel Prize equivalent in mathematics. This time also he has refused to accept the Millennium Prize, in spite of the worldwide appeal from various quarters and persuasion of a team of distinguished mathematicians of the CMI, who recently visited him at his St. Petersburg home, where he is staying with his ageing mother.

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PHYSIOLOGY OR MEDICINE



ROBERT G. EDWARDS

EVEN in a world beleaguered with population overgrowth, infertility is a highly agonizing medical problem at a personal level. Statistically, one out of every ten couples suffers from some form of infertility. This year's Nobel Prize for Medicine or Physiology has been awarded to Dr. Robert Edwards, Professor Emeritus at the University of Cambridge, UK for developing *in vitro* fertilization, considered as a "breakthrough that has helped millions of infertile couples world wide to have children". *In vitro* fertilization (IVF) is a process in which an egg cell is removed, fertilized out side the female body by adding sperm cells and returned to the female for conception.

The female reproductive organs consist of vagina, cervix, uterus, fallopian tubes and ovaries. Even the normal process of child bearing is a complex one. In about a week after the menstruation, the ovary releases an egg. In the next few days the egg matures, travels down the fallopian tube where it may meet the sperm cells released by the male during a sexual union. Out of the millions of sperm cells one may succeed in penetrating the egg and fertilizing it. The fertilized egg, called 'zygote' divides into 2,4,6,8.... cells to form an early embryo which implants itself in the uterus. As the pregnancy grows to full term, a child is born. All these steps are intricately timed and controlled by a number of hormones in the female.

But there can be many a slip between the cup and the lip. Infertility may be caused even if one of these steps is defective. This is where IVF has an important role to play.

A Bumpy Road

In the early 1950s, Dr. Min Chuch Chang of Worcester Foundation for Experimental Biology in USA had pioneered the *in vitro* fertilization in rodents. Robert Edwards obtained doctorate degree from the University of Edinburgh and in the early 1950s started working on the reproductive biology of rodents. He learnt the techniques of fertilizing rodent eggs *in vitro*.

Later he joined the National Institute of Medical Research, London and decided to investigate if similar methods could be used to fertilize human eggs to treat infertility. He acquired slices of human ovaries from surgeons, isolated immature eggs and started applying his earlier findings with rodent eggs. However, when he tried to coax the immature eggs to mature *in vitro*, he found the conditions quite different.

In an article "The bumpy road to human *in vitro* fertilization" published in *Nature* in 2001 he describes the various experiments he conducted to clarify how human eggs mature, the role of various hormones in the process and the exact time at which they could be fertilized successfully and also the conditions under which the sperm could be activated and had the capacity to fertilize the eggs. In these experiments he realized that eggs matured inside the human body were more suitable for *in vitro* fertilization than immature ones. Hence, he began collaboration with Dr. Patrick Steptoe, who had specialized in laparoscopy—a surgical technique that gives access to ovaries for retrieving mature eggs.

But the road was too bumpy, not only due to the complexity in the biological processes but also due to ethical considerations of that time. In the early days, Dr. Edwards and Dr. Steptoe had to fight a battle against organized groups who believed that such research should not be done at all. This included not only the Roman Catholic Church which thought that IVF was an affront on human dignity, but also many scientists who were, in addition to being skeptical also had misgivings that the children may be born with a high rate of abnormalities. Even the Medical Research Council of UK refused to fund their research. They had to seek private funding for their work.

Test Tube Baby

However, as a result of their sustained efforts over more than a decade under such demanding conditions, on 25 July 1978 Louise Brown was born in Britain as the world's first IVF baby, heralding a revolution in infertility treatment. Lesley Brown, mother of Louise Brown, had a block in her fallopian tubes and was unable to conceive even after nine years of marriage and approached Dr. Edwards and Dr. Steptoe.

During her natural menstrual cycle, the team retrieved a mature egg



Prof. Edwards with Louise Brown, her mother and son Cameron in 2008

from her fallopian tube through laparoscopy, fertilized it *in vitro* with her husband's sperm and placed it in culture medium for development. As the zygote started dividing, the 8-cell embryo was returned to her uterus. Since an earlier attempt had failed, she was monitored carefully for the entire term till the baby was born through a caesarean section.

Today, Louise Brown is 32 years old. Three years back she gave birth to a male child Cameron, conceived normally. (It may be a pleasant surprise to many readers that the second IVF baby was born in Kolkata in October 1978 just about three months after Louise Brown! However, due to a combination of governmental apathy and professional jealousy it did not receive enough attention denying the country its due credit-See Box).

Spurred by this success the team established the Bourn Hall Clinic at Cambridge, the world's first center for IVF therapy. Over the past three decades the Bourn Hall Clinic has been training hundreds of specialists from all over the world in IVF technique and also continually innovating new techniques to improve the success rate.

For example, in a normal menstrual cycle only one egg is released. However, in the present day IVF cycle, the ovaries are stimulated by treating the patient with certain fertility related hormones to release not just one but many eggs. Another course of hormonal treatment matures the eggs, which are then aspirated using, not laparoscope but a much simpler technique. In this an ultrasound-guided needle pierces the vaginal wall to access the ovaries and aspirate the mature eggs. At this time the eggs are surrounded by other types of cells. They are cleaned up and healthy looking ones are selected under a microscope to maximize the chances of fertilization.

Meanwhile, sperm cells are prepared by washing them to remove seminal fluid and inactive cells. They are mixed with egg cells in a ratio of

Dr. Subhas Mukherjee



India's and Asia's first and world's only second test tube baby was born in Kolkata on 3 October 1978. Her name is Durga or Kanupriya Agarwal. The man behind this pioneering effort was Dr. Subhas Mukherjee, Professor of Physiology, Bankura Sammilani Medical College, Kolkata. He was ably assisted by Dr. Sunit Mukharji, Cryobiologist at the Jadavpur University and Dr. Saroj Kanti Bhattacharya, Gynecologist and Obstetrics, Calcutta Medical College. Unfortunately what followed the historical event is a tragic story.

Born on 16 January 1931, Mukherjee earned the MBBS degree from the National Medical College, Kolkata and PhD in Reproductive Physiology from the Calcutta University. He went to the Endocrinology Research Institute, UK and worked on a new method of assaying luteinising hormone. He received PhD degree from the Edinburgh University in Reproductive Endocrinology. His research was concerned with the assay of gonadotrophins in rats. Incidentally, Dr. Robert Edwards also had received doctoral degree from the same university.

On coming back to India he worked at the NRS Medical College, Kolkata in various capacities as a lecturer, reader, and later as professor of Physiology. Continuing his work on embryos and early fetuses, he developed methods of inducing ovulation, first in animals and then in humans. This led to the development of an IVF technique that resulted in the birth of Durga.

He presented his IVF work at many national and international conferences and also corresponded with other workers in the area at the Harvard Medical School and Cornell University.

It is said that prophets are not honored in their own country. It was very true in the case of Dr. Mukherjee. His claim for successful *in vitro* fertilization in humans was greeted with suspension, disbelief, and disdain. The Government of West Bengal set up a committee to verify his claims. The committee was headed by a professor of radio physics and assisted by a gynecologist, a physiologist and a neurophysiologist—none of whom had any insight into the nuances of reproductive biology. The committee denounced his work, prevented him from publishing it and even denied him permission to attend a conference in Japan to present his work.

As a final blow, he was transferred to an ophthalmic department, about which he had no expertise, to prevent him from carrying out his research. Unable to bear the humiliation Dr. Mukherjee committed suicide on 19 June 1981. He was just 50 years old.

It took almost two decades for his resurrection. The credit goes to one Dr. T.C. Ananda Kumar, former Director of the Institute for Research in Reproduction, Mumbai. Dr. Kumar played a key role in the birth of what was officially India's first test tube baby (since Dr. Mukherjee's work was discredited) in 1986. He got hold of Dr. Mukherjee's papers and handwritten notes on IVF technique, studied them carefully and found them to be completely authentic. He not only freed Dr. Mukherjee from charges of fraud, but also gave credit to him as the first and the true IVF pioneer in India. Dr. Kumar has interviewed Durga and says she "is a well educated young woman and is well aware of the origin of her birth".

In a revealing article in the 10 April 1997 issue of the journal *Current Science* he states that Dr. Mukherjee had developed a method of *in vitro* fertilization that was successfully applied on a patient with damaged fallopian tubes and who was unable to conceive even 16 years after marriage. According to Dr. Kumar some of the remarkable achievements of Dr. Mukherjee were:

1. The first to use human menopausal gonadotrophin (HMG), a hormone to stimulate the ovaries.
2. The first to use transvaginal approach for retrieving mature eggs from the ovaries.
3. The first to cryopreserve human embryos, and
4. The first to successfully transfer the cryopreserved embryo to the uterus of a patient for successful implantation.

He points out that these techniques have now become standard methods in all IVF procedures, but unfortunately the credit going to various other workers in the field. Dr. Kumar says, "Ignorance of medical fraternity, bureaucratic arrogance and vindictiveness led to the loss of one our distinguished scientists....We lost our claim to have been the first in the world to have succeeded in not only freezing the human eggs *in vitro* but also having successfully cryopreserved the embryo, thawing it and leading to the birth of a normal baby..."

However, there was a small group of people who had faith in Dr. Mukherjee's integrity. Jadavpur University established Dr. Subhas Mukherjee Memorial Reproductive Biology and Research Institute in 1985 and also an Advanced Center for Cryogenic Research in order to perpetuate his memory. The Institute has published his biography **Architect of India's First Test Tube Baby—Dr. Subhas Mukherjee.**

In 2002, 21 years after his death, the Indian Council of Medical Research recognized Dr.Mukherjee's seminal contribution to IVF and recorded it in its document "National Guidelines for Accreditation, Supervision and Recognition of ART Clinics in India".

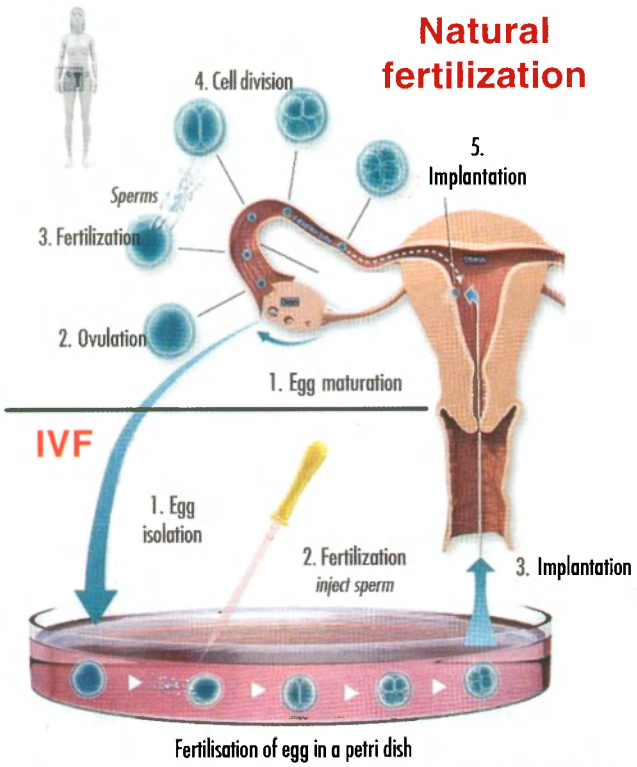
"Dictionary of Medical Biography" published in 2007 by Welcome Trust Center for History of Medicine at UCL, London also contains Dr. Mukherjee's life and work. During the 30th anniversary celebrations of IVF the Brazilian Medical Society in Sao Paulo recognized and honored Dr. Mukherjee for his incredible achievements.

(All these and many more details about Dr. Subhas Mukherjee can be found in the website http://www.drsubhasmukherjee.com)

75,000:1 in a culture medium for 18 hours—a process known as insemination. During this period one of the sperm cells penetrates the egg and transfers its DNA to fertilize it. Now the cell is fertilized and the zygote contains the complete human genome.

The zygotes are cultured in a medium that contains all the nutrients like glucose, pyruvate, energy-producing compounds, amino acids, nucleotides, vitamins, etc, at precisely controlled pH and temperature. Here they divide rapidly to form an early stage embryo with 6 to 8 cells. This takes about three days. At this stage an embryologist examines the embryos under a microscope and selects the best ones for transfer to the patient's uterus through a plastic catheter. Generally more than one embryo is transferred depending on the patient's age, health and other diagnostic information, to improve the chances of pregnancy. Since the process of fertilization takes place out side the human body, in a petridish, the process is called "*in vitro* fertilization" and the baby is colloquially referred to as a "test tube baby".

It is generally accepted that IVF pregnancies are more likely to yield twins and triplets than normal pregnancies. This is generally so because more than one embryo may be transferred to the uterus during the procedure. As for the general health of the IVF children is concerned, a number of surveys have shown that there is no significant difference between them and the normally conceived children, except that a greater number of IVF babies are born under weight. However, most of the IVF borns are still in their late twenties or early thirties. Hence, it may be too early to come to a final conclusion about the health effects of IVF.



Steps in natural and in vitro fertilisation

Meanwhile, IVF has become the final solution, not only for women with fallopian tube problems such as endometriosis, scarring, blockages, etc which cannot be set right by surgical procedures, but also for male infertility caused by low sperm count or poor sperm quality. In such cases a single sperm cell may be selected for quality and transferred into an egg by a technique known as intracytoplasmic sperm injection.

Extension of IVF

In recent years, IVF has developed many more dimensions. The extra eggs and embryos generated in an IVF cycle can be cold-preserved for many years in liquid nitrogen. Later they can be thawed and transferred to the same woman for a second pregnancy. In other cases a working woman could simply opt to have her own embryo frozen until she is financially and professionally in a sound position to have a child, without sacrificing her career. Or, they can also be used in embryo donation or surrogacy. In surrogacy the woman who provides the egg is not the same as the one who carries pregnancy.



Women who have early menopause, chromosomal and other genetic disorders and women who have undergone radiation therapy, chemotherapy or ovarian surgery for cancer cannot produce healthy eggs. In such cases, eggs harvested from a healthy woman can be fertilized by sperm from the patient's partner or a donor's sperm. The resulting embryo may be transferred to the patient's uterus. Recently, it was reported that a 42-year-old woman who was implanted with an embryo frozen for twenty years has given birth to a boy weighing 3.15 kg.

Even with healthy couples with a family history of inherited diseases and so at high risk of passing on to their offspring, IVF has served as a useful tool since the 1990s. In such cases the embryo can be screened for genetic defects before transfer.

Thus, IVF technique has caught up all over the world, for infertility is a global problem. Most of the groups that once objected to the procedure, except the Roman Catholic Church, have changed their views. Unfortunately, Dr. Patrick Steptoe died in 1988. Other wise he would have shared the Nobel Prize with Dr. Robert Edwards.

In selecting him for the Prize, the Nobel citation said, "Approximately four million individuals have been born thanks to IVF. Today, Robert Edwards's vision is a reality and brings joy to infertile people all over the world". As a testimony to this, the Nobel website is flooded with congratulatory messages to Dr. Edwards, from ordinary people, whom it has touched, including many from India.

Contributed by Dr M.S.S. Murthy, B-104, Terrace Garden Apartments, 2nd Main Road, BSK IIIrd Stage, Bangalore-560085.



PHYSICS

Andre Geim
Konstantin Novoselov



THE 2010 Nobel prize for physics could have easily gone to a school boy or girl residing anywhere in our planet. But it needed the ingenuity of two Russia born scientists to realize the importance of their discovery.

The 2010 Nobel Prize in Physics was awarded to Andre Geim and Konstantin Novoselov, both belonging to the University of Manchester, UK for discovering a two-dimensional allotrope of Carbon, which is now called Graphene.

Any body can make graphene – just take out the graphite inside an ordinary pencil and roll it on a scotch tape (popularly called cellophane tape or cellotape in India) and you will have an invisible layer of graphene, deposited on the scotch tape. The problem now is to isolate those areas where the layer is just one atom thick.



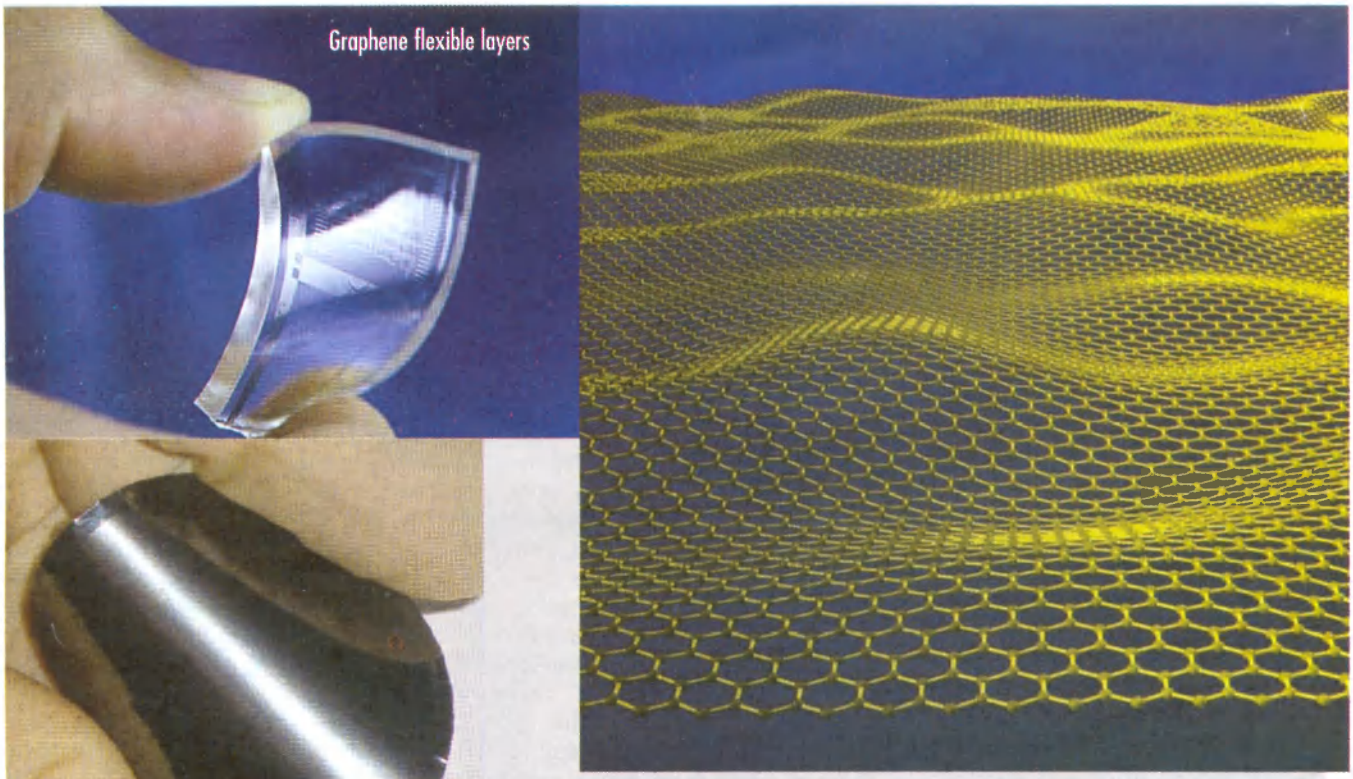
In the year 2004 (*Science*, 22 October 2004: Vol. 306. no. 5696, pp. 666–669), Geim and Novoselov took advantage of the optical effect of interference to locate the required graphene layer. If the flakes are deposited on silicon dioxide substrate of just the right thickness, one-layered graphene reveals itself through interference fringes. The Nobel laureates have also shown that carbon in such a flat form has exceptional properties that can be predicted from the remarkable edifice of quantum physics. As a material it is completely new – not only the thinnest ever but also the strongest.

Novoselov recounts how he and Geim made their discovery. The project began as an attempt to find a semi-metal semiconductor with a tiny overlap between the valence and conduction band. On paper, graphene was a promising candidate. The challenge was to make it. The first step toward that goal occurred when a member of Geim's lab, Oleg Shkliarevskii, informed Geim and Novoselov that he and his fellow researchers routinely made thin samples by applying Scotch tape to a material and then peeling it off. The next crucial step occurred by chance.

As a mount for the peeled-off graphite flakes, Geim and Novoselov chose a 300-nanometer-thick substrate of silicon dioxide. The thickness is fairly standard, but, as the researchers were to find out later, if it had been off by more than just 5%, they would have missed the revelation of fringes due to interference! The discovery of the one-atom thick graphene can be added to the list of serendipitous discoveries in physics made so far.

The band structure of silicon and other three-dimensional semiconductors is shown simplified in school textbooks as straight lines separated by a forbidden energy gap. But in reality, the band structure turns out to be wavy. Graphene's band structure consists not of wavy, gap-separated bands but of two cones – one upright, the other upside down – that meet at their apexes. The cones' straight sides imply that the electrons will behave like massless particles that speed through the material ballistically, as if they were photons travelling in free space. This accounts for the high mobility of charge carriers in graphene.

Geim and Novoselov confirmed graphene's band structure by measuring its conductivity as they varied a voltage that was applied perpendicular to the sheet. Other experiments followed, including the demonstration that graphene exhibits a quantum Hall Effect at room temperature. The main triumph of graphene is that it stands despite predictions made by thermodynamics. It was predicted that a sheet of material one atom thick is unstable above absolute zero. The slightest amount of thermal energy causes the sheet to buckle. Graphene is no exception, but the carbon–carbon bonds are strong enough to limit the buckling to waves no higher than 10 nm. Perhaps without a substrate, graphene can collapse.



Graphene flexible layers can have good use in computers.
The band structure of silicon and other three-dimensional semiconductors is shown simplified in school textbooks as straight lines separated by a forbidden energy gap.

Other research that followed yielded interesting properties of graphene. Graphene is almost completely transparent, yet so dense that not even helium, the smallest gas atom, can pass through it. Its honeycomb crystal lattice gives the material especially unique electrical properties. The great mobility of electrons in graphene allows for the creation of ultra-fast electronic devices. This property is thought to be a result of graphene's near-perfect atomic structure.

In addition to ultra-fast electronics, other potential applications include graphene transistors, integrated circuits, transparent conducting electrodes, and many more yet to be explored. Graphene-based computers will sooner or later replace the silicon-based computers. Since it is practically transparent and a good conductor, graphene is suitable for producing transparent touch screens, light panels, LCD displays and maybe even highly efficient solar cells that can power small cars.

But graphene has one significant disadvantage compared with the silicon used in today's chips. At present the conductivity of graphene can be modulated from an "on" state to an "off" state, though not as efficiently as it could be done with Silicon. This means that unlike silicon, which can be switched almost completely off, graphene continues to conduct a lot of electrons even in its "off" state. A chip made of billions of such transistors would waste an enormous amount of energy and therefore be impractical. But if all these shortcomings can be overcome in future, the fantastic nano world promises to put the entire *Encyclopedia Britannica* at our fingertips!

When asked what he would tell the public about his work, Novoselov replied: "That science should be fun, and you don't always need to do expensive multi-million dollar experiments to be on the cutting edge of research." Perhaps in simplicity, the discovery of graphene should rank among the great discoveries made by Sir C.V. Raman, which also had profound influence on other branches of science.

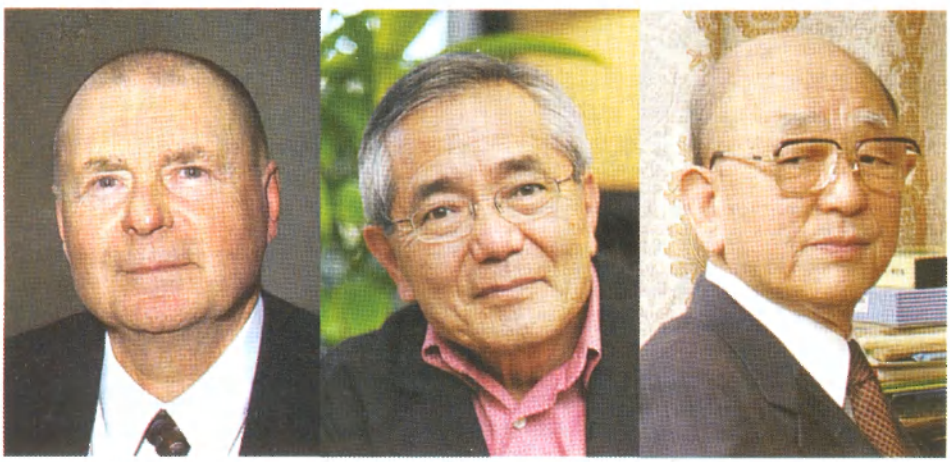
Andre Geim is a Dutch citizen, born 1958 in Sochi, Russia and Konstantin Novoselov is a British and Russian citizen, born 1974 in Nizhny Tagil, Russia. The award's 10 million Kronor ($ 1.4 million) purse will be equally shared between the two. The two also receive a citation and an invitation to the prize ceremonies in Stockholm on December 2010.

Contributed by Prof. K. Smiles Mascarenhas, Dean (Academic Affairs), Coimbatore Institute of Engineering and Technology, Narasipuram Post, Coimbatore–641109. A product of the Loyola College, Chennai and the Madras Institute of Technology, Chennai, he worked in the field of Radio Astronomy for about 17 years, and has been teaching for the past 16 years. He can be contacted at smiles51@rediffmail.com.



CHEMISTRY

Richard F. Heck
Ei-ichi Negishi
Akira Suzuki



LIFE on earth is built on carbon. Chains of carbon atoms, variously arranged, constitute the backbone of most of the molecules that form and regulate living systems. These molecules, large and small, of course contain several other elements too. But the greatest challenge to chemists, when they seek to replicate and even improve on nature's ability to construct carbon-based (organic) molecules has long been finding ways to make and break the chemical bonds between carbon atoms. Over the years, synthetic organic chemists have amassed a vast armamentarium of such reactions to use when building new molecular structures.

Many organic reactions are, however, rather prone to the formation of unwanted side-products owing to the fierce conditions or highly activated molecules required. The 2010 Nobel Prize in Chemistry rewards three chemists who have developed new methods for making carbon-carbon bonds, highly selectively, under relatively gentle conditions. All three have their reactions named after them. The Heck, Negishi and Suzuki reactions all depend on using palladium, a silvery metal, to unite two molecules, resulting in the formation of a new single bond between them. Over the last 30 years or so, these reactions have become staple and much-valued additions to the organic chemists' toolkit.



Richard Heck developed his palladium-based coupling reaction during the 1960s, publishing a series of single-author papers on the subject, before producing what became the standard protocol for the Heck reaction in 1972. In this, palladium acts as a catalyst, first taking hold of one molecule, then the other, and then joining and releasing the coupled pair while remaining itself unchanged by the procedure: a little like a dating agency. In the Heck reaction, the first molecule always contains carbon bonded to a halogen atom, such as chlorine, and the second always contains a carbon-carbon double bond. Remarkably, the reaction works at room temperature.

Ei-ichi Negishi and Akira Suzuki, who incidentally had both worked with Herbert Brown, the 1979 Nobel Laureate in Chemistry, extended the range of applicability of the Heck reaction, principally by developing ways of varying the second component molecule. The double-bond-containing molecule is replaced by an organozinc molecule in the Negishi reaction, and by an organoboron molecule in the Suzuki reaction. Together, these three reactions, and the variants that have since followed, have dramatically improved both the potential and the efficiency of synthetic organic chemistry and contributed substantially to the building of the complex molecules which contribute to so many areas of our daily lives, from agriculture to medicine.

By Adam Smith, Editor-in-Chief, Nobelprize.org. Reproduced from "The Nobel Prize in Chemistry 2010–Speed Read". Nobelprize.org. 1 Nov 2010, http://nobelprize.org/nobel_prizes/chemistry/laureates/2010/speedread.html

Dewdrops Two Steps from Home





FLORA AND FAUNA OF CSIR-SERC-CMC, *published by* Structural Engineering Research Centre, CSIR Campus, Taramani, Chennai-600113, Tamilnadu; paperback 454 pages

FLORA AND FAUNAIOF NATIONAL CHEMICAL LABORATORY (CSIR), *published by* National Chemical Laboratory (NCL), Dr. Homi Bhabha Road, Pune-411008; hard bound 156 pages

PUBLIC perception of scientific institutions or laboratories is fed on stereotypes and as such most people suffer from serious tunnel vision. If asked to draw a picture of a scientific laboratory, many will draw shelves with glass apparatus and sophisticated machinery. Rarely will anyone draw the picture of large roomy buildings set amidst jealousy-inducing greenery; lawns with rose gardens and semi-wooded areas where deer roam. Surely, such buildings cannot be scientific laboratories, come the incredulous response on seeing these temples of modern science.

However, scientists, who have the privilege of enjoying Mother Nature's best gifts on a daily basis, are aware about their good luck. Three laboratories under the Council of Scientific and Industrial Research (CSIR) have brought out two lavishly illustrated books on the biodiversity that flourishes on their campus. These laboratories are the National Chemical Laboratory (NCL) in Pune and the Structural Engineering Research Centre (SERC) along with the CSIR Madras Complex at Chennai.

CSIR-National Chemical Laboratory has recently celebrated sixty years and the book under review is a hardcover version of an earlier publication. Visitors have always been stunned by NCL's verdant campus. It is simply unbelievable to realize that in 1950 when the institution was being set up the area was barren of all vegetation. Similar is the case with CSIR-Structural Engineering Research Centre (SERC) where all members of SERC voluntarily contribute a day's labour—*shramdaan*—every year to ensure that the flora and fauna of their campus keeps thriving. This exemplifies a deep love for Nature as well as enormous respect for the Institute where they serve.

This love and respect for nature is evident in both the volumes under review. The scope is extraordinary: from termites to hyena, not to forget the fungi that grow on the grounds! The publication value of both books is of an extremely high order and the quality of colour photographs is superb.

The spirit of these two books is slightly different though. The book brought out by NCL is lyrical in appeal. Almost each species is welcomed on its pages with a suitable quotation taken from literature. The sources of these quotations range from the *Atharva Veda* to Rabindranath Tagore.

The book brought out by SERC-CMC provides a succinct and precise scientific description of the species that grace its pages. The descriptions, brief as they are, are complemented perfectly by the large colour close-ups. Thus the book is ideal for those who like to put a name to any new animal or plant that they spot.

The importance of both these books lies in the fact that globally species are dying out at an alarming rate. When trees vanish, with them die animals, smaller plants, herbs and creepers that depended on them for support and sustenance. Limited variety restricts the scope of future evolution, for Variety is the palette from which Nature chooses. Restricting variety is like paving the way for an apocalypse.

Documenting the biodiversity of the Institute where a person works is a welcome step. Not only does such a publication serve as a time capsule listing the species that were alive and well on a given date, but also once we learn the name of species that we see almost everyday, we are primed to take personal interest in its welfare. This interest translates into survival...for both the species. Because if biodiversity dies out, so will we. If it thrives, the human species will, too.

Awareness about the variety of animals and plants that share our immediate environment is the first step towards earning the broad perspective that can appreciate biodiversity on a global scale. Rabindranath Tagore once wrote (roughly translated from Bengali):

I traveled miles, for many a year,
I spent a lot in lands afar,
I've gone to see the mountains, the oceans I've been to view.
But I haven't seen with mine eyes
That just two steps from my home, lies
On a sheaf of paddy grain, a glistening drop of dew.

Many CSIR institutes have enviable biodiversity on their campus. It would be wonderful if these institutes brought out similar publications because that would provide enormous information about regional flora and fauna spanning the area from Jammu to Jorhat and Bhavnagar to Karaikudi.

Reviewed by Dr Sukanya Datta, Scientist NISCAIR posted to DG's Technical Cell, CSIR HQ; Email: sukanya@csir.res.in



Credited with the discovery of nuclear fission, one of the most important discoveries of the century, curiously Lise Meitner never made it to the ranks of the Nobel Laureates. Here's an insight into why it happened.

Lise Meitner

Lady Who Missed the Nobel

PARESH R. VAIDYA

OCTOBER is the Nobel season. The prizes for medicine, physics, chemistry and peace are announced in this month every year by the Nobel Foundation. Last year in October, prizes rained on women achievers. There were five women winners, two in physiology or medicine, one each in chemistry, literature and economics. The prizes in scientific disciplines were shared with other men, but three prizes for women in a single year compare extremely favourably with only 10 women during the entire 20th century!

The prizes were commenced in 1901 and in the first 100 years there were only two women in physics and three in chemistry to become laureates. Madam Curie was one person getting both physics and chemistry in different years. This makes only four women in the entire century!

This is not due to any bias against the fair sex, but because there were indeed few women in those days in the science labs. Only Europe that did research till the first half of the century was still conservative about women. Many universities did not admit girls at the graduate level till two decades into the century.

There is one thing noteworthy about the Nobel prizes; they are not known to have been given to undeserving candidates. But the converse is not true. There are many deserving cases that have been left out. While on the subject of women scientists, an obvious case was Lise Meitner. She is credited with the discovery of nuclear fission, one of the most important discoveries of the century, but the prize for fission went to Otto Hahn alone, who had done the experimental work.

Meitner explained his results theoretically and proposed this new phenomenon called fission i.e. the break up of an atom. If given the prize, in 1945 she could have become the second lady after Curie to get the coveted Nobel in physics. She can be called a victim of circumstances and perhaps human weakness that does not spare even scientists who are logical otherwise.

Born in Austria, Meitner came to Germany with a PhD in hand to work with the famous physicist Max Planck in 1907, but stayed back till 1938 when she had to flee. Chemist Otto Hahn was one of the first persons she met in Berlin and perhaps the last. While she was in the physics department of the Kaiser Wilhelm Institute (KWI), Hahn was in chemistry. Both eventually became the heads of their respective labs.

The initial part of her career was eventless and ordinary. Differences began to surface in her professional and personal life after 1934. Subsequent to the discovery of the nuclear particle neutron, the famous scientist Enrico Fermi had begun his work on creating artificial radioactivity in natural elements by bombarding them with neutron. He also bombarded heavier elements in the periodic table, like uranium, with the hope of getting 'transuranic' elements that did not occur in nature. This interesting work was replicated in many European labs then, including at Hahn's and Meitner's labs at the KWI, Berlin.

Personal difficulties were because she was born a Jew and Nazis had ascended to power in Germany. Though her family had converted to Christianity and she herself adopted protestant faith, the tag of Judaism made a big difference in her professional career also. All the institutes getting government grants were told to remove Jews from important positions. Meitner being an Austrian national was a foreigner, technically, and thus escaped this rule. But in March 1938 Hitler marched into Austria and annexed it to Germany. This took away Meitner's immunity and Hahn, who was the Director of KWI by then, was under pressure to drop her from the job. This was the time when they were at an interesting stage in neutron experiments.

The peculiarity of the situation was that, even if she would get a job outside Germany, she then needed a German passport and being a Jew, an exit visa under new Nazi rules. And she was denied both despite hard efforts put in by Hahn. In 1938, ultimately, she had to be smuggled out of



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the country into the Netherlands, on the night of 18 July under the kind eyes of a rare Gestapo police officer. After serving the country for 30 years and at the mature age of 59 this was indeed a sad moment for all her friends and colleagues.

She finally settled in Sweden, the country of Alfred Nobel and his prize. Hahn secretly met her in November, when he also discussed the work on uranium atom. They had intriguing results; as it happened with all other atoms, they expected that a new element in the vicinity of the original element would be formed by neutron bombardment of uranium atom. The farthest neighbour to uranium on the periodic table that could have formed was radium. But the outcome atom was not exactly behaving like radium. Totally confused, Hahn turned to Meitner in this letter in December 1938:

"It is now just 11 o'clock at night. At a quarter to twelve Strassman will be coming so that I can see about going home. The fact, there is something so odd about the radium isotopes that for the time being we are telling only you about it.... Our 'radium' isotope is behaving just like barium.... We all know that uranium nucleus can't really burst asunder to form barium...All highly tricky experiments. ... I have to get back to the counters now."

It was Christmas and her nephew Otto Frisch, a physicist, was visiting her. He describes in his autobiography how they go out to the woods in the snow, sit on a tree trunk and ponder over the problem of Hahn. They felt Hahn and his colleague Strassman had really broken the uranium atom. A new phenomenon of nuclear fission was now known to the world, when they reported their calculations in the journal '*Nature*'. Using Einstein's famous equation $E = mC^2$ they showed that a large amount of energy – 200 MeV (million electron volts) – should be getting liberated in this process of breaking of a nucleus.

Already a paper had been published by Hahn and Strassman on their part of the story in a German journal. What followed was an avalanche of discoveries in very rapid succession in view of the war and fears that this excess energy might be used by Germans to make a new weapon called 'super bomb'. As extra neutrons were indeed found in each fission, a process called chain reaction was postulated and later demonstrated by Fermi.

With the intervention of Einstein a project for making an Atom Bomb was established by America, bombs made, tested and dropped on Japan. What was away from the public gaze now came out into the open. It proved the veracity of the idea of fission for the world at large. And every one in the scientific community knew that the interpretation for Hahn's results came from Meitner and Frisch.

Then came the Nobel Prize. The 1944 prize was not yet declared due to the war and the chemistry committee decided to reconsider the decision of giving it to Hahn alone. But the final outcome was the same – it was to be Hahn alone. Neither his colleague Strassman nor Meitner and Frisch were there. Not only the Nobel foundation ignored her contribution but Hahn, her long time colleague, also changed his language thereafter. In a lame excuse he hinted that she was not there in Berlin at the time of the discovery. In some interview he even described her as a 'junior associate' just as he did for Strassman. When Birgit Aminoff, a scientist herself and the wife of a member of the board of the Nobel Foundation wrote to her to show solidarity, Meitner replied thus:

" Surely Hahn fully deserved the Nobel Prize in Chemistry. There is no doubt about it. But I believe that Frisch and I contributed something not insignificant to the clarification of the process of uranium fission – how it originates and that it produces so much energy, and that was something very remote from Hahn. For this reason I found it a bit unjust that in the newspapers I was called a Mitarbeiterin *of Hahn's in the same sense that Strassman was. Your letter, therefore, was a double present; a warm, understanding word can mean much. A thousand thanks for it."*

The Swedish word 'Mitarbeiterin' means a co-worker or a junior associate. No wonder it hurts when referred to like that after so much contribution. Niels Bohr recommended her name for the Physics prize for 1945 but it went to Wolfgang Pauli, an equally deserved and delayed case. He again nominated her name for Chemistry in 1947 and 1948 but it was ignored. There could be many reasons for not getting a Nobel. Her biographer Ruth Sime has dug deep to get information and stated that Manne Siegbahn, a Nobel Laureate in physics and on the Academy in Sweden making the decision was responsible for blocking her candidature. It was his lab that Meitner happened to go on her exit from Germany. Thus, there was an element of professional jealousy. Some say, if she had not migrated to Sweden but to some other country, she would not have missed the Nobel.

There is yet another likely reason. The Nobel Foundation has a rule that maximum three persons only can share a prize. If Frisch was to be included along with her, Strassman could not be left out. This is because both the famous papers had two authors each. This became four and not fitting the norms. Rather than dropping junior colleagues, they dropped Meitner! Or one can say, they dropped the interpretation part!

Whatever that be, the Nobel Prize was not everything about the recognition. She got a lot of love and attention from people till she lived, up to the ripe old age of 90. Scientific literature recognizes her as the inventor of fission. Germany, which drew her out at one time, called her back and established an institute in the joint names of both the colleagues, the Hahn-Meitner Institute for Physics. There cannot be a more effective expression for remorse.

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POLYMER TRIVIA

JITENDRA MATA

1. **Soft drinks and baby feeding bottles are generally made up of:**
   a. Polyester b. Polyamide
   c. Polyurethane d. Polystyrene
2. **The polymer used in the making of the bullet proof glass or in crush helmets is:**
   a. PMMA b. Lexan
   c. Nomex d. Kevlar
3. **A condensation polymer that is used in the manufacture of combs, electrical goods, fountain pen barrels, Formica tabletops, gramophone records etc. is:**
   a. Dacron b. Teflon
   c. Bakelite d. Glyptal
4. **The polymer which is used in the manufacture of tiers, cords, fabrics, and mountaineering ropes is:**
   a. PMMA
   b. Nylon-66
   c. Nylon-6 (Perlon)
   d. Low density polyethylene
5. **The polymer which is used in the manufacture of paints and lacquers is:**
   a. Terylene b. Nylon-66
   c. Glyptal d. Chloroprene
6. **The polymer widely used in transparent domes, skylights, aircraft windows, dentures and plastic jewelry is:**
   a. Chloroprene
   b. Neoprene
   c. Nylon-610
   d. Polymethylmethacrylate
7. **The polymer used in the making of protective covering for fire-fighters, astronauts and race-car drivers is:**
   a. Kevlar
   b. Nomex
   c. High density polyethylene
   d. Orlon
8. **The polymer used in the manufacture of carpets, textile fibers and bristles of brushes is:**
   a. Rayon b. Perlon
   c. Nylon-66 d. Terylene
9. **A condensation copolymer used in the making of non-breakable plastic cookery is:**
   a. PMMA
   b. Bakelite
   c. Melamine-formaldehyde resin
   d. Glyptal
10. **A polymer used as rayon clothing and toothbrush handles is known as:**
    a. PTFE b. Cellulose acetate
    c. Polyacrylonitrile d. Perlon
11. **Inorganic polymers nowadays widely used as oils, greases, resins and rubbers:**
    a. Dacron b. Silicones
    c. Polyurethane d. Polypropylene
12. **A condensation copolymer used to manufacture wash and wear fabrics, tier-cords seat belts and sails is:**
    a. Dacron b. Alkyd resins
    c. Polyisoprene d. Buna-S rubber
13. **A polymer used for preparing non-stick utensils, gaskets, pump packing, valves, and seals is:**
    a. Polyurethane b. Neoprene
    c. Polyisoprene d. Teflon
14. **A polymer used in the manufacture of containers, house wares, pipes, bottles and toys is:**
    a. High-density polyethylene b. Polystyrene
    c. Buna-S rubber d. PTFE
15. **A polymer that softens upon the absorption of water and is used to make contact lenses is:**
    a. Polyester
    b. Alkyd resin
    c. Neoprene
    d. Polyhydroxyethyl methacrylate (HEMA)
16. **A compound that polymerizes on exposure to atmospheric moisture to form a strong adhesive and is widely used by surgeons for enclosing incisions and by morticians for sealing eyes and lips is:**
    a. Cynoacrylate b. Isoprene
    c. Chloroprene d. Caprolactum
17. **A polymer used in the manufacture of hoses, shoe heels, stoppers etc is:**
    a. Polyisoprene b. Neoprene
    c. Polybutadiene d. Buna-S
18. **A polymer that is so strong that it is used in to make light weight bullet proof vests is:**
    a. Nylon-610 b. Kevlar
    c. Polyurethane d. Polyester
19. **Because of its low permeability to gas, it is used widely for inner tubes in automobile tyres:**
    a. Butyl rubber b. Buna-S
    c. Neoprene d. PVC

ANSWERS:

1. d	2. b	3. c	4. c	5. c	6. d	7. b	8. c
9. c	10. b	11. b	12. a	13. d	14. a	15. d	16. a
17. b	18. b	19. a					

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MIXED BAG

JYOTI RANJAN BISWAL

1. **The total genetic material within an individual is known as the:**
   a. Chromosome b. Gene pool
   c. Genome d. Genetic code
2. **Sound waves are:**
   a. Longitudinal
   b. Transverse
   c. Partly longitudinal, partly transverse
   d. Sometimes longitudinal, partly transverse
3. **Echo is a phenomenon of:**
   a. Reflection of sound
   b. Interference of sound
   c. Refraction of sound
   d. None of these
4. **The vibrations that a human perceives are called:**
   a. Subsonic vibrations
   b. Infrasonic vibrations
   c. Ultrasonic vibrations
   d. Sonic vibrations
5. **Regeneration in animals is seen in:**
   a. Hydra b. Planar
   c. Lizards d. All of the above
6. **The pacemaker of the heart is:**
   a. SA node b. AV node
   c. Kidney d. Lungs
7. **Evaporation of sweat from our body is an example of:**
   a. Exothermic reaction
   b. Endothermic reaction
   c. Chemical change
   d. Reversible reaction
8. **Pick the odd one out from the following:**
   a. Pancreas b. Thyroid
   c. Stomach d. Adrenal
9. **Which of the following processes is used to extract NA_2CO_3 on a large scale:**
   a. Belgian b. Sol ray's
   c. Hall's d. Nelson
10. **When pressure on a piece of ice is increased its melting point…..:**
    a. Decreases
    b. Increases
    c. First increases and then decreases
    d. Remains unchanged
11. **….Converts cooking oil into vegetable ghee:**
    a. Oxidation
    b. Hydrogenation
    c. Reduction
    d. Crystallization
12. **Which among the following dissolves gold?**
    a. Hydrochloric acid
    b. Nitric acid
    c. Aqua regia
    d. Sulphuric acid
13. **This kind of splitting where the large nucleus is broken into two smaller nuclei is called:**
    a. Fusion b. Combustion
    c. Fission d. Electrification
14. **Mercury forms alloys with metals known as:**
    a. Ore b. Amalgams
    c. Varnish d. Reduction
15. **In a vacuum, a coin & a feather are dropped simultaneously, which reaches the bottom first:**
    a. Feather b. Coin
    c. Any of the above d. Both at the same time
16. **What are black holes?**
    a. A huge black star with nil surface gravity
    b. A star with large surface gravity
    c. A star that has collapsed into itself and has powerful surface gravity
    d. A large star that has collapsed into itself and has no surface gravity
17. **First Telescope was invented by:**
    a. Dutch, Hans Lippershey
    b. Dutch, Newmann
    c. Dutch, Huygens
    d. Galileo
18. **Which element is an example of a noble gas?**
    a. Iridium b. Chlorine
    c. Krypton d. Nitrogen
19. **Hereditary disease in which blood fails to clot:**
    a. Anemia b. Beri-Beri
    c. Hemolysis d. Haemophilia
20. **What is a Richter scale?**
    a. It measures vibrations from earthquake
    b. It measures vibrations from volcano
    c. It measures vibrations from forest fires
    d. It measures moment of magma

ANSWERS:

1. c	2. a	3. a	4. d	5. d	6. a	7. b	8. c
9. b	10. a	11. b	12. c	13. c	14. b	15. d	16. c
17. a	18. c	19. d	20. a				

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NANDITA

Values are far more important in today's age of science and technology, than they probably were at any precious time in human history.

Values in Science

SCIENCE and technology touch every aspect of our lives. But can scientific knowledge discover values? Do facts of science help us determine what should be the end of human striving?

A fundamental feature of science, as conceived by most scientists, is that it cannot lead to judgments in the field of human values as it deals with facts. Science can give an extended life to a human through a transplant or erase all trace of human life through a mere explosion. Such facts exist whether we know them or not, whether we wish them or not, and in themselves are just facts of science, not values.

Whether such research is good or evil has meaning only within the context of our values: and determining the proper values for human beings is the task of philosophy, not science. These benchmarks can offer great comfort to scientists, who often see themselves as working in the privileged domain of certain and permanent knowledge. Recently, however, this notion of science as value-free has been challenged thereby raising questions about the authority of science and its methods.

Values Implicit in Science

The common characterization of science as value–free or value–neutral can be misleading. Scientists strongly disvalue fraud, error and "pseudoscience". At the same time, scientists typically value reliability, testability, accuracy, precision, generality, and simplicity of concepts. Science discovers unity in the wild variety of nature, or more exactly, in the variety of our experience. Scientists also value novelty, exemplified in the professional credit given for significant new discoveries. The pursuit of science as an activity is itself an implicit endorsement of the value of developing the knowledge of material world.

Scientists make complex decisions about which problem to pursue, what method to adopt and how to conclude an experiment. Taken together, these matters of judgment contribute greatly to the craft of science, and the character of a person's individual decisions helps determine that person's scientific style. Much of the knowledge and skills needed to make good decisions in science is learnt through personal experience and interaction with other scientists.

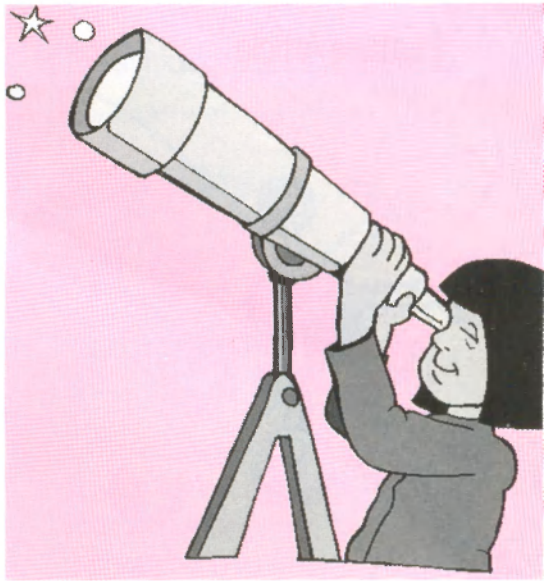
Many of the intangible influences on scientific discovery, curiosity, intuition, creativity, largely defy rational analysis, yet they are among the tools that scientists bring to their work. These values of science derive neither from the virtue of its members nor from the codes of conduct by which every profession reminds itself to be good. They grow out of the practice of science, because they are the inescapable conditions for its practice.

The pursuit of scientific knowledge implies a certain set of characteristically "scientific" values, but at the same time the relevance of other values in practice of science is not diminished. Science has been considered as a repository of human values; it provides a unique training in morality and appreciation for values by teaching truthfulness, open mindedness, reasoning, suspended judgment, acceptance of warranted conclusions and willingness to change one's opinion in the light of new evidence.

We need to re-examine the system of values under which our socio-political systems, operate – nationally and internationally. Values are far more important in today's age of science and technology, than they probably were at any precious time in human history.

The scientific community has a vital role to play in this matter, the first imperative being to promote its varied aspects at national and international levels of the human implications of Science.

To be more explicit, the aim of Science and Technology is not only to meet the materialistic needs of the country but also to create a better world with higher objectives and with a conception of global community.



Can Values Influence Science?

Historians, sociologists, and other students of science have shown that social and personal beliefs – including philosophical, thematic, religious, cultural, political, and economic beliefs – can shape scientific judgment in fundamental ways. Science proceeds through the agency of individuals and not unexpectedly, perhaps, individual scientists express the values of their cultures and particular lives when they engage in scientific activity.

Many a time scientific data have been manipulated and interpreted in favor of a particular gender, race or a class. This exemplifies how values can and do enter science and shape its conclusions. To interpret the entry of values into science in cases such as these, one must focus on individual cognitive processes.

According to Ronald Giere, specially valuable is the notion of cognitive resources - all the concepts, interpretive frame works, motivations and values that an individual brings from his or her personal experience to scientific activities. Cognitive resources affect how an individual notices certain things, finds some things as especially relevant, asks questions or poses problems, frames hypotheses, designs experiments, interprets results, accepts solutions as adequate or not, etc.

An individual's cognitive resources will be drawn from his or her culture, limiting what any one person can contribute to science. Further, because each person's biography and intellectual training are unique, cognitive resources will differ from individual to individual, even within the same culture. Hence, one may well expect disagreement or variation in interpretation in any scientific community. Far from being an obstacle to developing consensus, however, the variation of a community can be a valuable resource. That is, only conclusions that are robust across varying interpretations will tend to be widely perpetuated, feels William Wimsatt.

Even religion, sometimes cast as the antipode of science, can be cognitive resource that contributes positively to the growth of knowledge. For example, Einstein's rejection of quantum mechanics as an irreducible description of nature, summarized in his insistence that "God does not play dice", seems to have been based largely on an aesthetic conviction that the physical universe could not contain such an inherent component of randomness.

According to Douglas Allchin, James Hutton's theological views about the habitability of the earth prompted his reflections on soil for farming and on food and energy, and led to his observations and conclusions about geological uplift, "deep time", the formation of coal, and what we would call energy flow in an ecosystem.

Ethics and Science

Objective science emphasizes the conceptual, rational and empirical. As it is commonly practiced, it is outward looking towards the external world, analyzing, explaining and predicting things and events through discursive thoughts that fragment the whole into smaller and smaller components.

Further more, mainstream science is materialistic and mechanistic. Logical and scientific reason confines itself to the field of the 'known'; it ignores the 'knower', the subject, the Self. This explains the limitations of its knowledge, the partial character of the truths it finds, and the relative character of the physical reality it reveals.

Many eminent scientists – Eddington, Heisenberg, Schrodinger and Einstein – have stumbled upon another mode of knowledge, which they have called the intimate, or direct, or intuitive, or insight, or non-dual knowledge. Victor Weisskoff, an eminent physicist, in the Introduction to Hideki Yukawa's (Japanese Nobel laureate in physics) book *Creativity and Intuition* wrote, "Chinese thinking emphasizes the intuitive component – the importance of inspiration in scientific thinking."

Hideki Yukawa, while tracing the history of science back to ancient Greece, wrote, "There not only were intuition and abstraction in complete harmony and balance with each other, but there was also no such thing as the estrangement of science from philosophy, literature, and the arts." Outstanding western thinkers – Russell in England and Sorokin in USA – have warned that modern civilization cannot survive unless it is inspired by ethical and spiritual values. Therefore, objective science must restructure itself to take subjective research in its fold.

Humanism and Science

Both science and technology are so much a part of the cultural, economic, social and political affairs of all modern nations that lack of understanding can have dangerous consequences leading to unmitigated disaster. On the other hand, the future holds great promise, if science is pursued with dedication and technology is wisely used in the



Science

true interests of the community, and not for narrow sectional ends dictated by selfishness and mistrust.

This needs the amalgamation of science with humanism. The scientific community has a vital role to play in this matter, the first imperative being to promote its varied aspects at national and international levels of the human implications of Science. To be more explicit, the aim of Science and technology is not only to meet the materialistic needs of the country but also to create a better world with higher objectives and with a conception of global community. The time has come for nations to act in this vision.

This is not a difficult task if the nations are really keen to realize the truth that the "World is one, in fact and in potentia" and if they could have the perception of the unity amidst diversity, a harmony amidst chaos and if they are prepared to listen to the note of concord throughout the discordant sounds in this universe. Such perception comes from the microcosmic mind provided it is in perfect harmony with the macrocosm (external). Knowledge of this kind will help science and technology to achieve the higher objectives and will thus bring peace to the whole universe.

Scientists make complex decisions about which problem to pursue, what method to adopt and how to conclude an experiment.

In present times, as never before, there is a greater need to integrate scientific values with other ethical and social values. Science can help identify unforeseen consequences or casual relationships where ethical values or principles are relevant. In addition, individuals need reliable knowledge for making informed decisions. Ethical values are required to assess whether the risk is 'acceptable' or not. Communicating the nature of the risk to non-experts who participate in making decisions can thus become a significant element of science. Scientific facts and ethical values will have to function in concert for the development of a healthy and peaceful society.

Today, we need to ponder deeply over the problem, that the scientific search for truth has not assured the advance of civilization. Inventions intended to relieve toil, and to control the forces of nature, which should have given to a fuller and more satisfying life, have been perverted into forging instruments of destruction. The paradox of poverty amidst plenty mocks us in the face. In one part of the world food and clothes are being discarded and thrown away, while in another part half-naked people are begging for food.

In India, we subsist on a regular diet of female feticides and improving medical technologies, starvation deaths and expanding network of cell phones, dowry deaths and speeding digital revolution, child marriage and virtual classrooms.

It is not difficult to get at the root of this problem. In respect of scientific knowledge and its applications to the problems of life, each generation stands on the shoulders of the preceding one, but in respect of values no comparable development is noticeable.

Russell, in his essay on 'machines and emotions', has remarked that Science has done wonders in mastering the laws of the physical world, but our own nature is much less understood, as yet, than the nature of stars and electrons. When science learns to understand human nature, it will be able to bring happiness into our lives, which machines and the physical sciences have failed to create.

It is distressing to know that when enormous forces are available in the world for beneficial purposes, and for raising human standards to undreamt of heights, people are still thinking of war and conflict, and are still maintaining economic and social structures that promote monopoly and create differences in standards of wealth between various groups and peoples. What we need today is a fresh thinking on the human situation, on the kind of automated, globalised world that is being built, making human beings secondary in the scheme of things.

We need to re-examine the system of values under which our socio-political systems, operate – nationally and internationally. Values are far more important in today's age of science and technology, than they probably were at any precious time in human history.

Maurice Wilkins summarized one of his philosophical notions and wrote, "Science is a human activity. The question of good and bad, of human virtue (ethical/spiritual) relates to every human activity. How therefore can science, being a human activity, be separated from all virtues and values (ethical/spiritual)?"

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Water body infested with water hyacinth (Photo by Dipanjan Ghosh)

WATER HYACINTH
Befriending the Noxious Weed

DIPANJAN GHOSH

It is high time we befriended the noxious water hyacinth rather than keeping it away.

IT is blacklisted as a notorious aquatic weed in India and other tropical countries, and often designated as 'Bengal terror', 'blue devil', 'invasive weed', 'noxious plant', 'plant pest', 'prohibited aquatic weed' and so on. The target of such abusive nicknames, water hyacinth, is a dreaded waterweed often blamed for choking water bodies and creating problems for other aquatic plants and animal inhabitants. However, lately its role in environmental cleaning is being truly recognized.

Water hyacinth or *Eichhornia crassipes* (Mart) Solms, belongs to the family Pontederiaceae. The genus 'Eichhornia' was named after J.A. Fr Eichhorn (1779-1856), a Prussian Minister of Education while the species 'crassipes' means 'thick foot' in Latin. This monocotyledonous floating herb completes its life cycle within one year in seasonal water bodies although it is a perennial under favourable conditions. Water hyacinth is found mainly in freshwater bodies ranging from small ponds and ditches to large lakes and rivers. The plant even pesters rice fields.

Water hyacinth forms a sprawling expanse of green embellished with lilac to violet flowers on the water bodies. Its well-developed submerged fibrous roots are devoid of root caps. But root pockets, like loose thimbles, keep the root apex covered. A rather striking presence of blue anthocyanin pigment in the root tips of Eichhornia is also noticed. Stoloniferous stem is short, unbranched and with swollen internodes enveloped by sheathing leaf bases. The leaves are simple, large, broadly ovate or cuneate, deep green, coriaceous and with spongy inflated petiole; the leaf blade is smooth and glossy due to a waxy surface.

Eichhornia flowers generally in August–September in the tropics. As this plant is sensitive to cold and is unable to survive below 6.5°C, flowering also seems to be influenced by temperature. Flowers are bisexual, slightly irregular, with six-lobed perianth united below into a tube and free above. The upper most tepal is with yellow, blue-bordered central splotch. Male sex organ comprises three long and three short stamens. The female sex organ, on the other hand, comprises three carpels in united condition. After the flowering is over the inflorescence bends down and the fruits develop under the water. The fruit is a three-celled capsule containing many minute, ribbed seeds.

Water hyacinth is a very charming flowering plant, aptly called 'Cinderella of the plant kingdom'. Brazil is considered to be the native land of this plant. Attracted by its beautiful flowers, water hyacinth later became naturalized by man in many warm areas of the world like Central and North America, Africa, Asia, Australia and New Zealand. It is believed to have been introduced in India during 1890 by the British colonials.

With increasing popularity of water gardening and home ponds, water hyacinth is now sold by many western nurseries for its unusual appearance, attractive flowers and

Water hyacinth is an unstoppable plant colonizer that cannot be eradicated completely.



Spike of water hyacinth flower – 'Cinderella of the plant kingdom' *(Photo by Dipanjan Ghosh)*



Spongy petioles help water hyacinth to float
(Photo by Dipanjan Ghosh)

Water hyacinth can also provide a cheap yet effective way of removing arsenic from drinking water.



Multifarious root system of water hyacinth
(Photo by Dipanjan Ghosh)

ability to remove nutrients from the water. However, escape from captivity is a very common feature of this invasive weed. Further more, the magical ability of propagation has enabled it to conquer huge expanses of water bodies throughout the tropics every year.

Unpleasant Activity

Water hyacinth is called the worst aquatic plant in the world. It imposes both physical and ecological problems and has economic impact also. Its mats clog waterways making boating, fishing and almost all other water activities impossible. The risk of flood increases when drainage is impaired. The choked water bodies increase the possibility of water borne diseases and become breeding grounds especially for mosquitoes, which spread malaria and encephalitis.

Eichhornia infestation also prevents sunlight and oxygen from getting into the water. As a result fishes and other aquatic animals perish when water bodies are choked with this weed. The phytoplanktons or surface dwellers also die due to dearth of light. Water hyacinth alters immersed plant communities by pushing away and crushing them (an acre of this weed can weigh more than 200 tons) and/or eliminating native plants the animals depend on for shelter and nesting. Moreover, the huge quantity of Eichhornia with trapped silt and dust make the water bodies shallow, even forming small islands where reeds and even woody plants invade.

Water hyacinth has a distressing impact on agriculture, particularly on rice cultivation. Farmers face enormous problems in rainy season, when irrigation water flushes in tonnes of water hyacinth into the field. Luxuriant growth of water hyacinth also hampers hydroelectric power generation. Bird sanctuaries and wetlands infested with Eichhornia face serious problem as birds avoid these silted up water bodies affecting the tourism business as well as causing ecological imbalance.

The entire Eichhornia plant is highly adapted to an aquatic mode of life. Some adaptive features and their impacts are discussed below:

a) Numerous fibrous roots with a small pocket at the tip are a special adaptation to balance in the water and also to absorb maximum nutrients. Such an efficient root system has made Eichhornia a broad-spectrum mitigator, showing tolerance as well as accumulation of a large number of metals together.

b) The petioles become characteristically swollen and develop spongyness, which provides buoyancy to the plant. Smooth, shining and frequently wax-coated leaves of water hyacinth protect from chemical and physical injuries and also prevent the water clogging of stomata. Perhaps for this, water hyacinth is usually seen unharmed in water bodies filled with toxic substances.

c) The prolific growth of Eichhornia is very much dependent on its vegetative reproduction, which mainly occurs either by stolon production or by budding. Sexual reproduction occurs rarely through seeds.

d) The flowers remain open only for a day and wither away even if pollination has not taken place. Moreover, the flowers are mostly self-pollinated. Hence, neither a partner plant nor any pollinating agent is essential for completing the life cycle.

e) Eichhornia is a very potent hydrophyte, showing resistance to diseases and a large number of pests.

Such adaptability has empowered water hyacinth to occupy any type of fresh water habitats throughout the world.

Any Benefits?

The ever-increasing population of Eichhornia as well as its impact on the society has made it indubitably one of the most annoying weeds of the tropics. It costs much energy and money in controlling water hyacinth. Today humans are making every effort, even using remote sensing to survey and monitor this weed, ultimately realizing that the copious growth of Eichhornia can be restricted only through its utilization in various aspects.

The water hyacinth may be a promising possibility for solving needs of animal feed. It contains most

Prize Puzzle

TALE OF CITIES

Here are a few lines that depict the tale of the writer's predicament as he moved from one city to the other. Can you figure out the names of the cities in each case? To give you an idea, two solutions are given.

I lived in a city that held as much as it could	(**CAPA CITY**)
So I moved to another that repaid what it should	( )
The third had very little, with not much to be found	( )
The fourth was very boring, with no change in the sound	( )
The fifth was a jungle; wild beasts roamed in the street	( )
The sixth was so foggy you could not see past your feet	( )
The seventh was on the move; I could barely keep the pace	( )
The eighth was so evil; a whole city in disgrace	( )
The ninth was off-center; the people were bizarre	(**ECCENTRI CITY**)
The tenth was quite truthful; where honesty is par	( )
The eleventh was so wise; the acumen hurt my brain	( )
So I settled in a twelfth, because it was so plain.....	( )

There are three prizes of Rs. 500/– each for three correct entries. In case there are a large number of correct entries, the prize winner will be selected through a draw of lots. The decision of the Editor, *Science Reporter*, will be final.

Last date for the entries to reach us: 30-12-2010

Puzzle Corner
Science Reporter
National Institute of Science Communication And
Information Resources, CSIR, Dr. K.S. Krishnan Marg
New Delhi-110012

Your Name : .....

Address : .....

.....

.....Pin Code : .....

Age : .....Email : .....Sex : .....

Occupation : ☐ Student ☐ Housewife ☐ Teacher ☐ Professional ☐ Retired ☐ Other

Educational Level: ☐ Primary ☐ Secondary ☐ Graduate ☐ Postgraduate

*Please fill up the questionnaire at the back

*Please note: Now you can even send your answers on a photocopy of this page.

FAKE BAG

Suppose you have five bags filled with the same type of coins and a weighing machine. One of the bags is completely filled with fake coins, the other bags contain only real ones. A real coin weighs 10 gram and a fake one 11 gram.

How will you find the bag with the fake coins and what is the minimal number of times you need to use the weighing machine in order to find the bag with the fake coins?



Answer .....

PUZZLING EQUATIONS

Solve the following "LOGIC" equations by logic and replace all the letters with suitable digits.

1. LOGICLOGICLOGIC = P(PPPPPQQQQR)(28351)

   _____ = _____

2. LOGICLOGIC = (AA)(DEDA)(86485)

   _____ = _____

3. (LOGIC)(LOGIC) = HIOLOGIC

   _____ = _____

4. 6(LOGICA) = ICALOG

   _____ = _____

5. (LOGICCLOGI)(ACG) = LLLLLLLLLLL

   _____ = _____

6. (L+O+G+I+C) (L+O+G+I+C) (L+O+G+I+C) = LOGIC

   _____ = _____

Contributed by Mr. Sawinder Singh,
H.No. 106, Ward No. 6, Street No. 1, Rulia Ram Colony, Gurdaspur–143521, Punjab

Solutions to the puzzles published in the October 2010 issue:

PRIZE PUZZLE:

Broken Cubes

Options 2 & 6

Pyramid of Genetics

1. T
2. GG
3. PEA
4. GENE
5. KAPPA
6. OPERON
7. PLASMID
8. ANAPHASE
9. KARYOTYPE
10. CENTROMERE
11. PROKARYOTES
12. ENDONUCLEASE
13. TRANSCRIPTION
14. GYNANDROMORPHS
15. PARTHENOGENESIS
16. SEMICONSERVATIVE

No Square Puzzle



The names of the prizewinners based on a draw of lots from among the correct entries are:

1. **Arindam Mahapatra,** C/o Mr Ashok Kumar Mohapatra, Office of Assistant Engineer, PH Subdivision, Shahadev Khunta, Balasore-756001

2. **N.M. Rajan,** Corporation Bank, SM Street Branch, PM Taj Road, SM Street, Calicut-673001

3. **Mahesh Nair,** 9/11 Mahishkapur Road, Durgapur, West Bengal-713205

Congratulations all the winners!

M. SALEEMUDDIN

The Ethanol Enigma

What was synthesized as a pickling chemical millions of years ago by the yeast turned out to be a magical molecule that continues to influence the lives of humans in many ways. Ethanol is widely used as a disinfectant, medicine and for partying. It is currently being touted as the most potential renewable fuel and replacement for petrol.

SOMEWHERE around 60-80 million years ago, long before Homosapiens made their glorious appearance on planet earth, the tiny unicellular yeast tasted the ripe fleshy fruits hanging temptingly from the flowering plants and was overwhelmed.

The colourful sugar-rich pulpy fruits were evolved by plants to reward animals that could move reasonable distances and help them in seed dispersal, but certainly not for the yeast to feast upon. For the selfish yeast however the fruits were like manna from heaven, which it hated to share with others. The yeast devised one of the cleverest strategies ever to render the fruits toxic to competitors, while keeping them fit for its own consumption; it learnt to convert sugar present in the fruits to ethanol.

In order to generate ethanol, the yeast engineered its own metabolism of sugars by adding two hitherto unknown additional enzymes—pyruvate decarboxylase and alcohol dehydrogenase—to the billion-year-old, time-tested pathway of sugar breakdown, glycolysis. During glycolysis sugar molecules are broken down mainly to lactic acid accompanied by the release of a small fraction of their energy, without the need of oxygen. The new pathway evolved thus enabled the yeast to convert sugar to ethanol, which was quite toxic to other organisms, without compromising with energy generation.

Yeasts also learned to extract energy by metabolizing the ethanol molecule using a second version of the alcohol dehydrogenase. The idea of converting sugars to ethanol and then using the ethanol to generate energy instead of using the sugars directly makes little sense. But by doing so the yeast accomplished the pickling of fruits with ethanol and addressed the problem of toxicity by conveniently metabolizing the alcohol.

This monopoly of the yeast over the fruits however did not last very long. While the fermented fruits were quite toxic to most creatures, fruit flies soon came up with their own form of alcohol dehydrogenase that helped them not only tolerate high concentrations of alcohol in the yeast-infested fruits, but also use ethanol as an excellent source of energy. Most higher animals including humans also have metabolic machinery to metabolize ethanol to a reasonable extent.

Ethanol is a tiny organic molecule belonging to the class alcohols and contains a hydroxyl group attached to a two-carbon hydrocarbon. The word alcohol is believed to be drawn from the Arabic word 'Al-Kuhl' originally meaning a fine powder of antimony produced by distillation. The term was used subsequently by alchemists to describe all refined products obtained by distillation. Ethanol has a very low melting point – 114.1 ^{0}C – making it very useful in the construction of thermometers for use at very low temperatures. Because of the same reason ethanol is also used widely as an antifreeze compound in automobile radiators. All beverage ethanol and more than half of that used industrially is produced by fermentation processes mainly by the yeasts.

Ethanol generated from sugars has not only helped the yeast survive millions of years, but also unwittingly continues to affect the lives of humans and a small number of animals. It is interesting that the study of ethanol production by yeasts contributed remarkably to the development of modern biology.

In the year 1856, Monsieur Biogo, father of one of the students of Louis Pasteur, who owned a large factory that manufactured wine from sugar beet juice sought his (Pasteur's) help in solving the problem faced by him. Some of the fermenting vats were turning sour, causing losses of thousands of Francs a day. This drew Pasteur's interest in yeasts and its

Advantages of Ethanol as Biofuel

- Completely biodegradable
- Emits fewer green house gases
- Can replace harmful fuel additives
- Can be produced anywhere in the world from home grown raw material
- No need to rebuild machinery that runs on petroleum





A drunken Loris ?

metabolism, which contributed remarkably to the understanding of anaerobic carbohydrate metabolism. Pasteur successfully addressed the problem of Monsieur Bigo, suggesting a simple remedy for the souring of the wine vats. The problem could be completely overcome by heating the vats at moderate temperatures, a strategy recognized as Pasteurization and widely used even today.

Today partying cannot be imagined without free flowing ethanol-rich liquors. Economies of several countries including Germany and Austria continue to depend on wine making and manufacture of other forms of liquor like beer and whisky. Alcohol has been a part of human civilizations from times immemorial, as an important component of ceremonies and religious meets. Humans apparently learned the art of making alcoholic beverages long before they could read and write. The oldest wine sample available was dug out during excavation from a vineyard near the town Speyer in Germany and is believed to be from approximately 325 A.D.

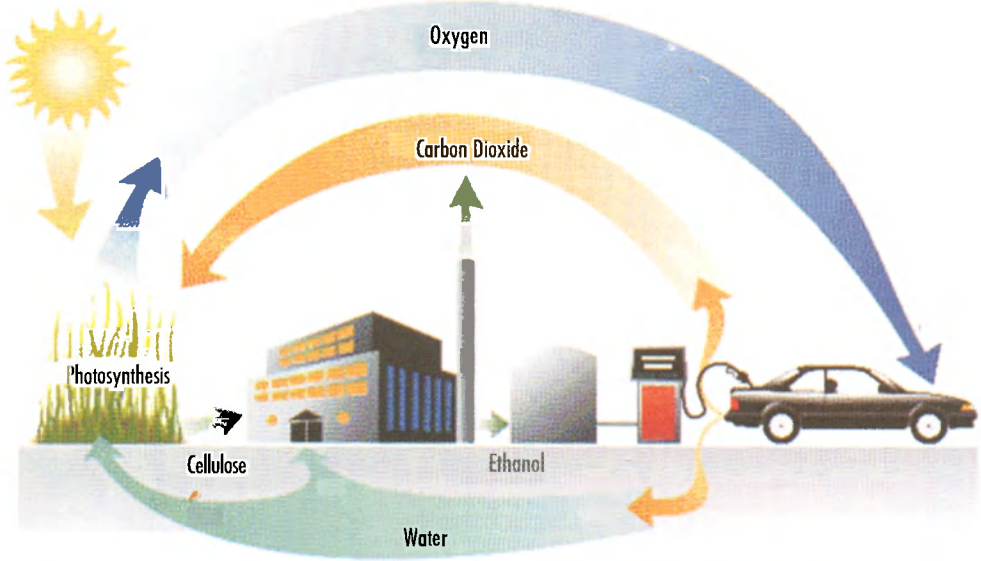
The influence of alcoholic drinks on humans has been so strong that the Romans even had a God of wine—Bacchus. Our love-hate relationship with alcoholic drinks continues even today. While nations dread alcoholism, consumption of alcoholic drinks continues to rise proportionally with progress of economies globally.

Moderate drinking of ethanol has however been recognized to favorably affect human health. The French 'Paradox' is about the protective effect of wine against cardiovascular complications. An average French consumes much more saturated fat than their American counterparts, yet rates of death from coronary heart disease among males aged 35–74 years were markedly lower in France, according to a study conducted in 2002. It has been suggested that high red wine consumption by the French primarily accounts for the trend.

More recently, researchers from the University of Texas, Austin in a study based on over 2,000 adults of age groups 55-65, observed that unlike heavy drinkers, those who consumed 1-2 drinks of wine daily survived significantly longer compared even to the teetotalers.

We may not possibly be the lone creatures on the planet in our predilection for alcoholic drinks. While contradictory observations abound regarding animals binging on fermented fruits, a relatively recent report shows that in the Malaysian rain forests a few small mammals including the pen-tailed tree shrew and slow Loris enjoy the alcohol-rich nectar of the flowers of bertam palm during the night. The nectar contains alcohol, produced by fermentation by the yeast having content of ethanol comparable with that of beer. Apparently, the plant favors the little animals with a cocktail

Carbon Dioxide Recycle with Ethanol Fuel





During glycolysis sugar molecules are broken down mainly to lactic acid accompanied by the release of a small fraction of their energy, without the need of oxygen.

in return for pollination of its flowers. It is not unlikely that alcoholic nectar lures the animals to return for a second round. So, while the yeasts aimed at making several animals shun fruits that it fermented, some plants cleverly used even the addictive nature of the alcohol to their advantage.

Currently ethanol is also in the limelight in its new avatar as the most potential biofuel. While utility of ethanol as fuel has long been recognized, focus on its development as a fuel for automobile has not been consistent mainly due to intermittent fall in crude oil prices.

Way back, in 1925, Henry Ford made his famous statement that alcohol was the 'fuel of future'. In the same year a motorcar fuelled entirely by ethanol was driven a distance of over 400 km between Rio de Janeiro and Sao Paulo. Brazilian Auto manufacturers and energy planners were the first to introduce the idea of flexi fuel cars and today all the petrol sold in the country is "Gasohol" containing around 23% ethanol. In Brazil, car owners have the option of running their vehicles on E85, containing 85% ethanol and 15% gasoline or even 100% ethanol.

According to a plan unveiled by the former American President George W. Bush, U.S. will be replacing 20% of gasoline with ethanol by producing and importing a whopping 135 billion liters of the biofuel.

In India ethanol-blended petrol, rated as green fuel, is slowly making its presence felt. Blending of ethanol with petrol in the country was envisaged in 2004 but not all the manufacturers supplied ethanol to oil companies, hence, the Union government's ethanol-blending programme could not be implemented. The country's demand for ethanol is massive—105 crore litre. Blending of ethanol will not only save expenditure on imports, but also reduce emission.

Bioethanol can be produced from almost any kind of biomass, although technologies available can work with sugar-rich sources like cane sugar or starch-rich corn.

Production of ethanol from sources fit for human consumption has also invited criticism in view of the risk of pushing food prices high. In the words of the Cuban president Fidel Castro, "Transformation of food in to fuel is a monstrosity". Attempts therefore continue to identify inexpensive sources of biomass like agricultural wastes that are rich in cellulose and unfit for human consumption.

According to Alfred Szware, Technology Advisor to the Sugar Cane Growers Agroindustry Union in Sao Paulo, "the true future of biofuels lies in cellulose".

Global sources of starting material for ethanol production by fermentation

Country	Source
Brazil	Sugarcane
USA	Corn kernel, corn stover
Malayasia, Indonesia, Thailand	Palm oil
Canada	Corn, wheat
China	Sweet potato

Prof. M. Saleemuddin is Coordinator of the Interdisciplinary Biotechnology Unit, Aligarh Muslim University (AMU), Aligarh-202002, U.P. He has worked on post-doctoral assignments/visiting fellowships at the Nuclear Research Center, Juelich, Germany, University of Hanover, Germany, University of Leeds, UK and as a Fulbright Scholar at the Johns Hopkins University, USA.

Amborella:

The Earth's First Smile



The flowering plant *Amborella trichopoda* is perhaps the most-primitive flowering plant on Earth. It is the sole member of the Family Amborellaceae. Angiosperms or flowering plants are believed to have diverged from Gymnosperms – about 130 million years ago – roughly about as long ago as *Amborella trichopoda's* history began.

The study of flowering plants is difficult because flowers are fragile and there are very few fossil flowers. Charles Darwin too had major problems trying to figure out the hows and whens of the evolution of flowering plants and called the appearance of flowering plants "an abominable mystery." If only he had studied *Amborella trichopoda* closely.

Amborella trichopoda grows naturally only in the rain forests of New Caledonia—an island in the South Pacific. It is a small shrub. *Amborella* plants are either male or female. The plants bear tiny bunches of greenish-yellow flowers. Interestingly, the flowers possess not petals, but petal-like organs called tepals. Male flowers have 9-11 tepals and 11-22 stamens, which carry pollen. Female flowers have 5-8 tepals, a few sterile stamens called staminodes, and four to six carpels.

The fruit is a red coloured berry with a single seed. Cross-pollination between plants is required for fruit production. The evergreen leaves are alternately arranged and have slightly serrated margins. *Amborella* does not have vessels for conducting water. This is a primitive feature as almost all other AngiospermS show the presence of such vessels.

It is now known that within the first fifteen million years of Angiosperm history, three major lineages of flowering plants—monocotyledons, eumagnoliids and eudicotyledons—were established. This was a time of tremendous experimentation in nature and enormous variations in floral and vegetative characteristics. *Amborella* is probably the last remnant of one of the most ancient lineages of Angiosperms. Genetic studies show that it is either *at* or at least, *very near* the base of the flowering plants. Simply put, *Amborella* represents a line of flowering plants that diverged very early from all the other species of flowering plants still alive. It is the closest we have got to a living ancestral flowering plant.

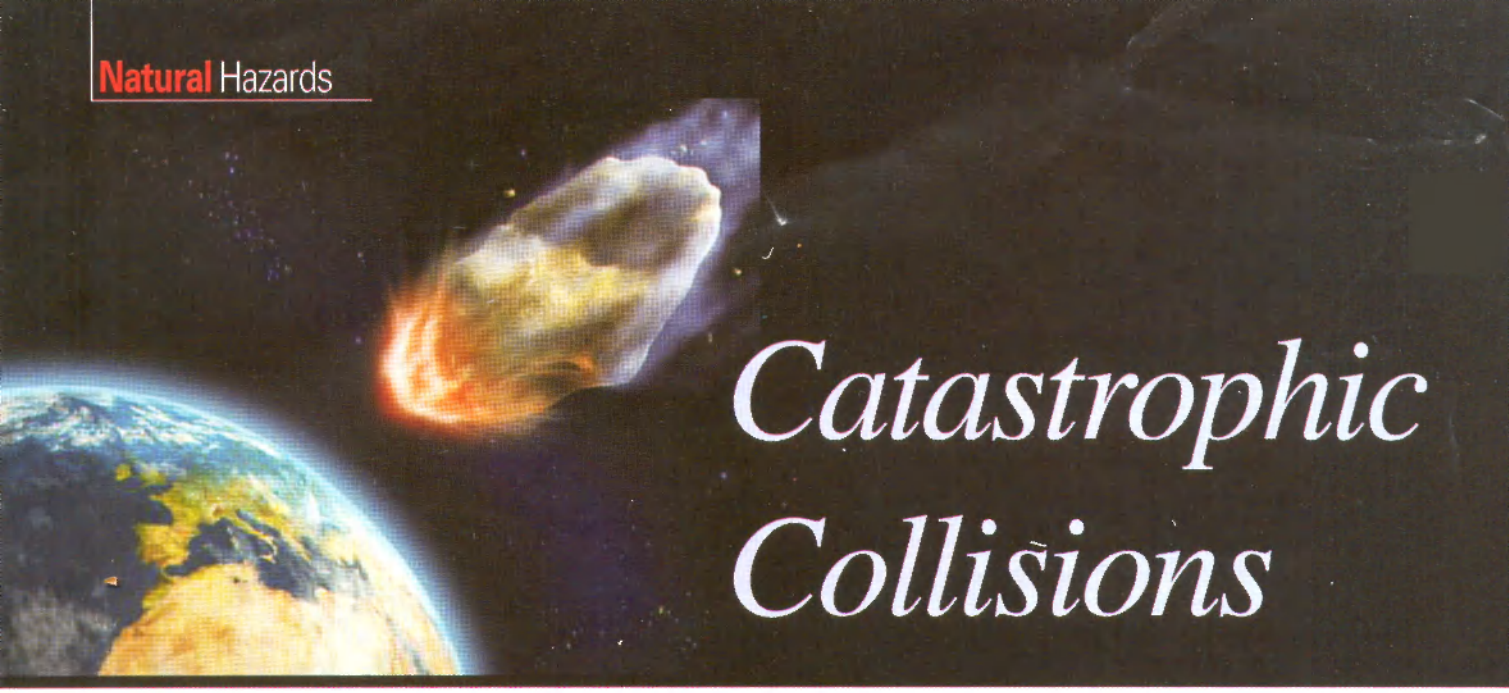
Flowering plants are distinguished from all other plants by the differences in reproductive biology. A study published in *Nature* (2006) by a team led by Prof. William E. Friedman, University of Colorado, USA, focused on a novel type of embryo sac that is seen in *Amborella*. Apparently, *Amborella* has one extra sterile cell that accompanies typical egg cells in the embryo sac—a discovery that harks back to *Amborella's* non-flowering ancestors. The discovery of the unique configuration of the egg apparatus has been compared to being, "... akin to finding a fossil amphibian with an extra leg." At the very least Prof. Friedman's discovery suggests that the reproductive structure of the plant may be the "missing link" between angiosperms and more-ancient gymnosperms such as pines, ginkos, and cycads.

Despite an unbroken chain of existence that has lasted for 130 years, the risk that *Amborella* runs is that of extinction. Its geographical range is severely restricted and the challenges of environmental degradation and pollution cannot be ignored. However, a small gene bank of *Amborella* is also maintained in USA.

In 1975, Virginia and Todd Keeler-Wolf, students at the University of California, Santa Cruz (UCSC) USA, shipped back some samples of *Amborella* under the guidance of Ray Collett (Founder Director UCSC). The Arboretum at UCSC still supplies scientists with botanical samples they need for studies on *Amborella*. The *Amborella* genome is being sequenced. More information is available at: http://www.amborella.org/.

Henry David Thoreau said that the Earth laughs with flowers; if so, *Amborella* was the Earth's first smile.

Dr Sukanya Datta
Scientist NISCAIR posted to Director General's Technical Cell, CSIR HQ
Email: sukanya@csir.res.in



Catastrophic Collisions

Despite our Earth-bound perceptions, our home planet is but an insignificant speck in space. It is fragile and vulnerable to hits from asteroids or space rocks on a collision course. Asteroids range in size from those like Ceres with a diameter of ~1000 km to those the size of sand grains.

Space rocks on a collision course with Earth are called meteoroids. When a meteoroid enters the atmosphere, friction causes it to heat up and glow. We call it a shooting star or a meteor. Small meteors burn up completely as they pass through the atmosphere. Larger ones end up on Earth as a meteorite. Impact craters are formed when a large meteoroid or comet crashes into a planet.

Although meteoroid strikes are frequent, atmospheric incineration protects against all but the really serious strikes. One such massive impact left its imprint on Mexico's Yucatan Peninsula as it struck Earth with an explosive energy equivalent to 100 trillion tonnes of TNT. Thankfully, there were no human beings round when the event occurred—only dinosaurs.

Crash Consequences

Today, 65 million years later, all that remains as a reminder of this deadly impact is a crater about 180 km in diameter and 900 metres deep. It is surrounded by a circular fault about 240 km in diameter. It was the view from space that provided the first clues to this crater buried under almost a kilometre or so of new rock and sediments. Without satellite images we would never have been able to name Chicxulub as the impact site.

However, it is not difficult to recreate what must have happened the day the meteor struck. Imagine seeing a huge ball of fire on the horizon speeding towards you, *"twenty times faster than a speeding bullet."* Any living being frozen to the spot by fear would have been grilled by the sizzling heat even from afar. Then would have come the actual impact itself blasting debris into the atmosphere, cutting off sunlight and causing a darkness-at-noon phenomenon. The impact would have triggered large-scale fires, huge earthquakes, and continental landslides, which in turn, would have unleashed devastating tsunamis.

A study reported in March 2010 has gathered powerful evidence that this single cosmic strike 65 million years ago led to the sudden extinction of more than half of all species on the planet, including the dinosaurs, bird-like pterosaurs and large marine reptiles.

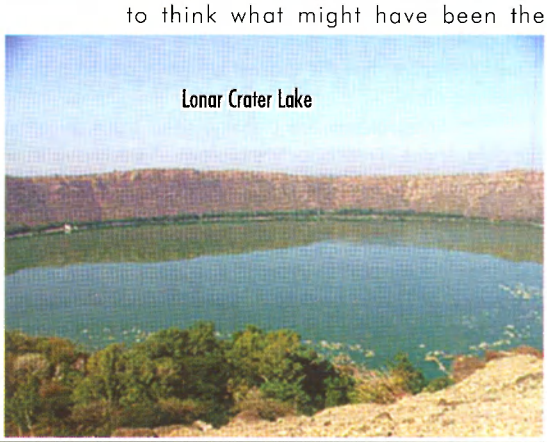
Contemporary Contact

Admittedly, an event that happened 65 million years ago does tend to make Earthlings rather complacent. It is fitting therefore to remember that 30 June 2008 marked the 100th anniversary of what is called the Tunguska event.

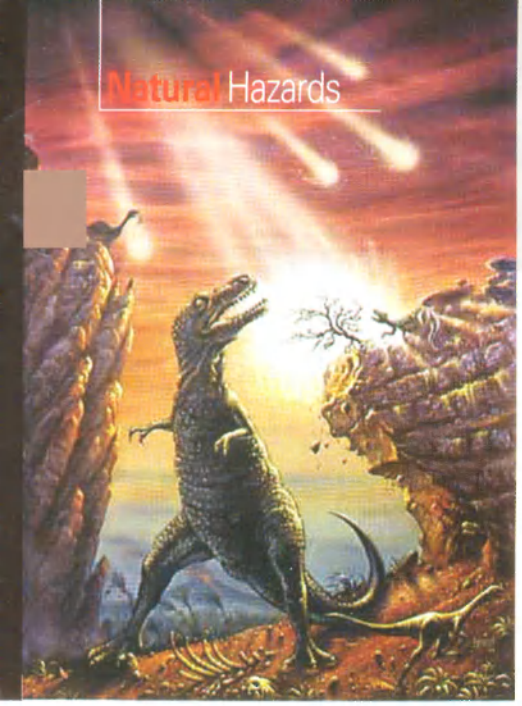
According to Don Yeomans, manager of the Near-Earth Object Office at NASA's Jet Propulsion Laboratory, *"It is the only entry of a large meteoroid we have in the modern era with first-hand accounts."*

It is estimated that the 99 million kg space rock entered Earth's atmosphere travelling at a speed of about 53913 km per hour. It was sizzling hot and it heated the air surrounding it to over 24700 degrees Celsius. At a height of about 8534 metres, the enormous pressure and tremendous heat caused the asteroid to fragment and burn up. This resulted in a fireball and released energy equivalent to about 185 Hiroshima bombs. The resulting seismic shockwave was recorded as far away as England.

The actual impact levelled 1335 square km of Siberian forest. The uprooted trees lay in a radial pattern like matchsticks pointing away from the epicentre of the strike, their braches and bark stripped bare. In 2008, scientists announced that it was likely that a comet had crashed into Earth at this remote location. In retrospect it is scary to think what might have been the



Lonar Crater Lake

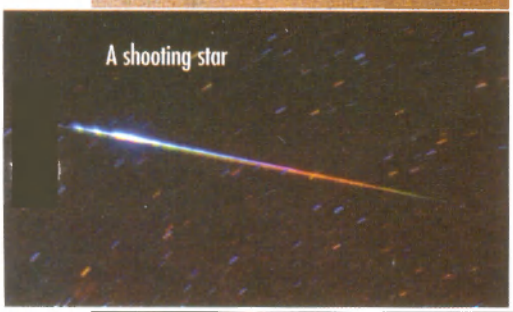


consequences on human lives if the impact had occurred in a heavily populated megacity instead of in a remote forest.

Colossal Collisions

- The ***Barringer Crater*** (Meteor Crater, Canyon Diablo, Arizona Crater) in Arizona, USA is the result of an impact event that happened ~20,000-50,000 years ago and is the first confirmed asteroid crater on Earth. It is named after Daniel M. Barringer who was the first to suggest that it was the result of an impact. The size of the crater is huge: over a kilometre across.
- Although well known to the Aborigines, ***Wolfe Creek Crater*** was formally identified in 1947. It is considered the second largest crater in the world from which meteorite fragments have been collected. Wolfe Creek Crater measures roughly 880 meters in diameter. According to NASA, it is estimated that the crater formed some 300,000 years ago when a meteorite weighing more than 50,000 metric tons struck the Earth at an estimated 15 kilometres per second. Not only did it blast out the massive crater, it shattered rocks well below the ground surface.
- The ***Aorounga Crater*** has a diameter of about 17 km. Scientists think that it was formed as part of a multiple-impact event that scarred northern Chad several hundred million years ago.
- The ***Roter Kamm*** impact crater in Namibia was formed by a meteorite that collided with Earth approximately 5 million years ago. It is 2.5 km in diameter and is 130 m deep.
- It is estimated that impacts such as the one in Mexico occur (on average) about once every 100 million years. Earth has already faced about five such events.





Country's Chronicle

Although mentioned in ancient texts, India's Lonar Crater (Maharashtra) was formally identified in 1823 by a British officer named C.J.E. Alexander. It is the result of a meteorite impact that occurred between 35,000 and 50,000 years ago. Lonar Crater is approximately 150 m deep and has a diameter of 1,830 m. The crater rim rises about 20 m above the surrounding land. A lake occupies the crater. That it is an impact crater became clear when Maskelynite, a kind of naturally occurring glass that is only formed by extremely high-velocity impacts, was found here.

Chances of Crash

Scientists keep a close eye on what they call PHA or **P**otentially **H**azardous **A**steroids, which are space rocks larger than ~100m that can come closer to Earth than 0.05 AU (~7,480,000 km). On 11 May 2010 there were 1116 PHAs under observation. Some of these asteroids have names, for example, Apophis; all have numbers, for example, Asteroid 2003QQ47 or Asteroid (29075)1950DA.

PHA-Earth close-approach tables are maintained and monitored regularly. Scientists use a risk-assessment scale (from 0 to 10) to assess the possibility of collision. An object with a value of zero or one has virtually no chance of causing damage on Earth; a 10 means a certain global climatic catastrophe...probably the only time getting a ten on ten is not something to cheer about! Scientists reassure us that the word *"Potential"* in PHA does not indicate that the impact will happen; rather, it denotes Possibility.



However, this does not mean that a smaller strike cannot happen even as you are reading this.

However, this does not mean that a smaller strike cannot happen even as you are reading this. Ask Dr. Frank Ciampi whose office in Virginia, USA was hit by a tennis-ball-sized meteorite on 21 January 2010. It was simply chance that nobody was hurt. The meteorite was travelling at a speed of 350 km/h when it struck. It penetrated the roof; passed through one wall partition and then a particle board ceiling before finally breaking into three pieces on the floor of an examination room, which had been occupied by patients just a brief while earlier.

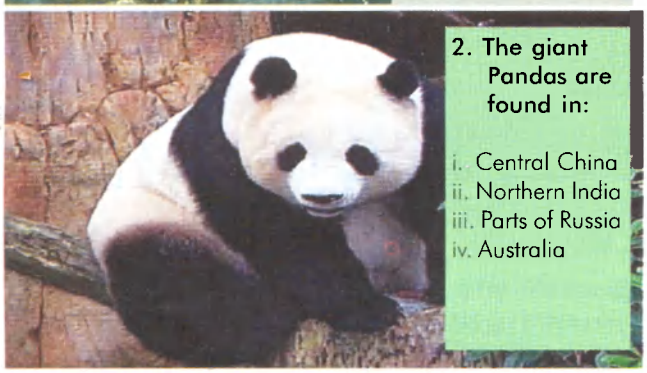
Dr Sukanya Datta
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Nature's Beauty

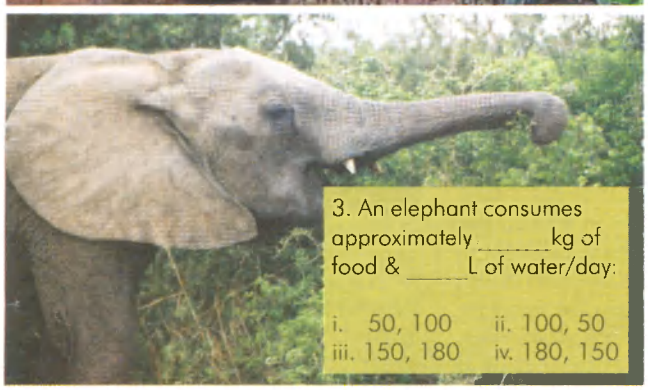
INDU MEHTA & PRONOTI



1. The largest frog is:
   i. African Clawed Frog
   ii. Goliath
   iii. Forest Frog
   iv. Bull Frogs



2. The giant Pandas are found in:
   i. Central China
   ii. Northern India
   iii. Parts of Russia
   iv. Australia

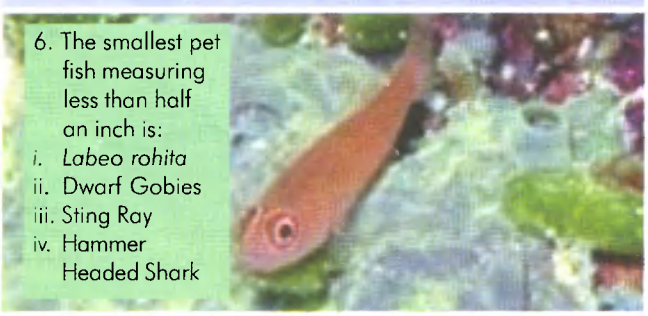


3. An elephant consumes approximately _____kg of food & _____L of water/day:
   i. 50, 100 ii. 100, 50
   iii. 150, 180 iv. 180, 150



4. The tallest of all dogs measuring 110 cm is:
   i. Irish Wolf Hound
   ii. Afghan Hound
   iii. Dogo Argentino
   iv. Pug

5. Favorite food of Giant Pandas are:
   i. Rats ii. Guava
   iii. Bamboo shoots iv. Mango Leaves



6. The smallest pet fish measuring less than half an inch is:
   i. *Labeo rohita*
   ii. Dwarf Gobies
   iii. Sting Ray
   iv. Hammer Headed Shark

7. The biggest bear Kodiak weighs upto:
   i. 500 kg
   ii. 1000 kg
   iii. 650 kg
   iv. 780kg





8. The smallest dog Miniature Yorkshire Terrier weighs about:
   i. 1 kg
   ii. 500 g
   iii. 1.5 kg
   iv. 200 g



9. An insect that can lift 50 times its own weight is:
   i. Cockroach
   ii. Dragon fly
   iii. Housefly
   iv. Ant

10. The smallest bear Sun Bear weighs upto:
    i. 15 kg
    ii. 40 kg
    iii. 27 kg
    iv. 55 kg





11. The longest living captive birds are the Sulphur Crested Cuckatoos of Australia that live up to:
    i. 5 years
    ii. 80 years
    iii. 15 years
    iv. 200 years



12. The bird that can fly straight up, down and backward is:
    i. Crow
    ii. Parrot
    iii. Eagle
    iv. Humming Bird



13. Turkey hens lay 12 eggs in:

i. a day
ii. a year
iii. a month
iv. a week



14. Flying Frogs are tree frogs that can glide through the air. They have _____on their fingers for gripping.

i. Sticky Discs
ii. Claws
iii. Mucous
iv. Modified Skeleton



15. The biggest nest is of ____ measuring 4m deep and 7.5 m long. It has enough separate cavities for hundreds of pairs of birds.

i. South African Weaver Bird
ii. *Tyto alba*
iii. *Pavo*
iv. Kingfisher



16. Dolphins live in groups called _____ up to 300 strong.

i. Herds
ii. Colony
ii. Flock
iv. School



17. The Frill-necked Lizard is found in:

i. Australia
ii. South America
iii. Africa
iv. England



18. Pet fish ____ have sharp teeth and are voracious flesh eaters.

i. Butterfly Fish
ii. Guppies
iii. Piranhas
iv. Angel Fish

19. The Paradise whydah of Africa has a spectacular tail that is _____ times larger than its body.

i. Ten
ii. Four
iii. Fifteen
iv. Two



20. _____ is one of the very few lizards that live in the sea. They can stay under water for upto an hour.

i. Gecko
ii. Maine Iguana
iii. Varanus
iv. *Hemidactylus*



21. The world's largest insect is _____ of Indonesia, which grows up to 33 cm long.

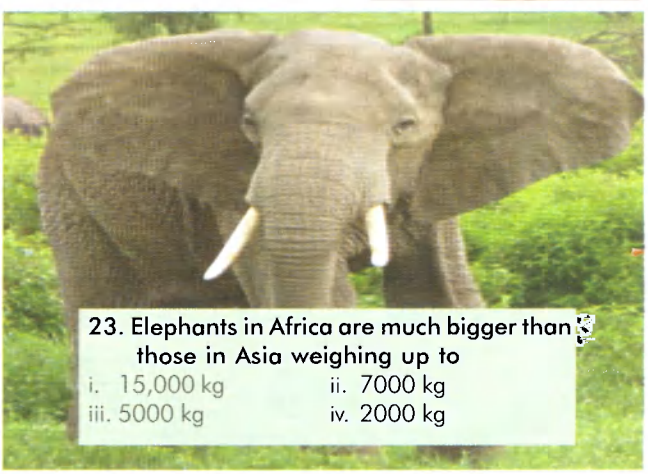
i. Giant Stick Insect
ii. Cockroach
iii. Honey bee
iv. Grasshopper



22. Front teeth of rodents are razor-sharp for gnawing, they are:

i. Incisors
ii. Molars
iii. Premolars
iv. Canines





23. Elephants in Africa are much bigger than those in Asia weighing up to

i. 15,000 kg ii. 7000 kg
iii. 5000 kg iv. 2000 kg

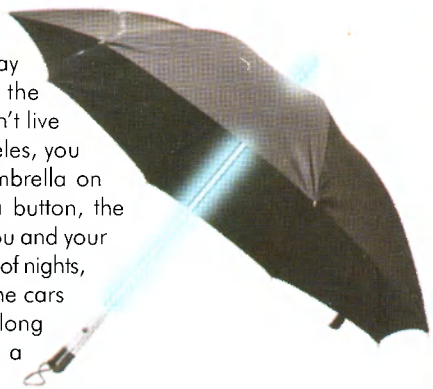
ANSWERS:

1. ii, 2. i, 3. iii, 4. i, 5. iii, 6. ii, 7. iv, 8. ii, 9. iv, 10. iii, 11. ii, 12. iv, 13. ii, 14. i, 15. i, 16. iv, 17. i, 18. iii, 19. ii, 20. ii, 21. iv, 22. i, 23. iii,

Contributed by Dr (Mrs) Indu Mehta and Ms Pronoti, Department of Zoology, GGDSD College, Sector-32/C, Chandigarh-160030 (UT)

LED Umbrella

In the pre-apocalyptic future, the air will be so thick, it will be dark in the middle of the day. Coupled with the almost constant rain, you'll need to find a way to stay dry and light your way to the noodle shop. Even if you don't live in a quasi-futuristic Los Angeles, you can still have the coolest umbrella on the street. With a push of a button, the shaft lights up, illuminating you and your path. Now, even in the darkest of nights, you're a lot more visible to the cars on the street, making your long walk home through the rain a lot safer.





Light Bulb with Special Glow!

It is a glow-in-the-dark light bulb trapped inside a solid acrylic brick. The Glow Brick recharges from energy in natural sunlight during the day and glows at night. Not only that, it is actually made with a real light bulb. The glow-in-the-dark pigment is trapped inside a real light bulb and the light bulb is encased in a solid block of Acrylic resin. The mysterious optical effect is caused by light diffracting in the tiny space between the glass of the light bulb and the resin. In a darkened room, or at night, it comes to life with a tranquil and subtle glow emanating from the pigment inside the light bulb.

Hands Warmer

Who says you can't enjoy the great outdoors and stay warm? The Hand Warmer is a rugged, metal hand warmer by the folks who make our favourite brand of lighter. It has a high-polish finish and a sleek, thin design so it easily fits into pockets, and it's virtually odourless and stays warm for up to 12 hours. Besides, it's reusable with Zippo lighter fluid and includes a convenient filler cup and warming bag. Whatever you're doing out there in the cold, keep a Hand Warmer in your pocket and you'll stay happy and warm doing it.



Coffee Cup Power Inverter

The Coffee Cup Power Inverter is a conveniently-shaped power source that converts the car's DC power into two 120-volt AC outlets. It can provide 120 Volt AC power from any cigarette lighter socket. Perfect for powering or charging TV's, DVD players, game consoles, cell phones, and other portable electronics. This coffee cup also has a USB charging port providing 500mA of power. The unique coffee cup shape fits nicely in today's auto/boat/truck cup holders, preventing it from moving around inside your vehicle.



Self-Powered Emergency Tool



The Self-Powered Emergency Tool is a 12-in-1 unit featuring a built-in hand crank, so you can generate power when and wherever you need it. Never worry about batteries for your flashlight, radio or about charging your cell phone and MP3 player. The flashing red light, panic button and motion activated security alarm help to protect you from harm – at home, while biking, camping, hiking, fishing, hunting and boating. If you get lost, the compass and signaling mirror can help you find your way or lead others to find you. There's even a built-in storage compartment for pills, matches and other small items.

ACROSS

2. A compound that changes its structure and colour in response to its environment (9)

5. Study of lakes and other bodies of open fresh water (9)

6. Sound waves audible to human ear (5)

7. Practice of ensuring that bacteria are excluded from open sites during surgeries (7)

11. Historical sequence of changes that occurs in a given species during course of its evolution (9)

13. A force that tends to cause rotation (6)

14. SI unit of amount of a substance (4)

16. The tendency of an object to remain in a state of rest or uniform motion (7)

19. Video Cassette Recorder (3)

20. The vascular tissue in plants that conducts water and dissolved nutrients upwards from the root (5)

23. Plant succession developing in a particular habitat (4)

24. Mixture of chemical compounds chosen to maintain a steady pH (6)

25. A force that opposes the motion of a body (8)

26. Destruction of red blood cells (10)

DOWN

1. A piece of software that can replicate itself and transfer itself from one computer to another (5)

3. Scientific study of birds (11)

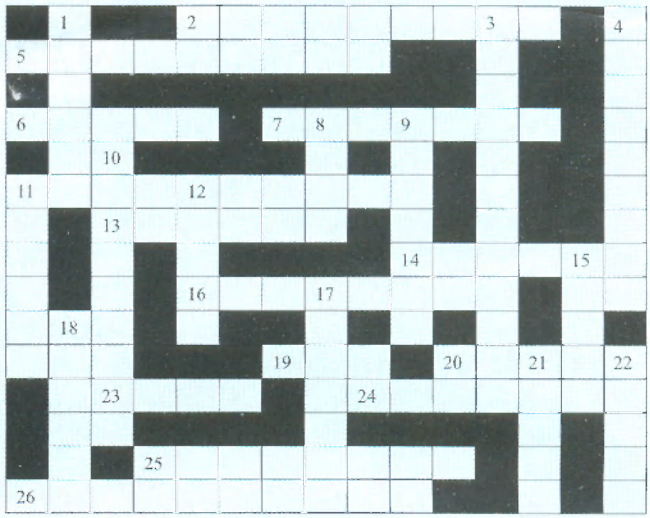
4. Study of the structure of the universe (9)

8. Unit of subjective loudness (4)

9. Extra Chromosomal DNA found in bacteria (7)

10. A jelly like material inside a cell and surrounding the nucleus (9)

11. The state of a number being either even or odd (6)



12. The path of earth around the sun (5)

15. SI unit of magnetic flux (5)

17. Defective growth of bones in children caused by lack of vitamin-D (7)

18. Liquid component of blood (6)

21. Simple machine consisting of a rigid rod pivoted at the fulcrum, for shifting or raising heavy load (5)

22. Molten rock material beneath the Earth's surface from which igneous rocks are formed (5)

Contributed by Shri Santosh Kumar Mishra, S/o Narayan Mishra, At-Beleswar, PO-Nayabazar, Dist-Cuttack, Orissa-753 004

Solution to November 2010 Crossword

C	D	R	O	M					R		B		
	A		C	O	M	P	I	L	E	R		I		B
	T			D		R			C	O	B	O	L	O
	A		R	E	M	O	T	E	O		A	S		O
E	P	R	O	M		C			R		S		14	L
M						E			D		I			E
U	P	E	R	T		S	T	A	C	K	C	A	D	A
L				V	L	S	I					D	E	N
A	U	D	I	O		O	P	E	R	A	N	D		A
T						R				L		E		L
O	M	24		25		T	O	R		U		R		G
R	O					R		A	L	G	O	L		E
	U	29				A		M			U			B
	S			E		C	R	E	G	I	S	T	E	R
N	E	T	W	O	R	K					B			A